ADVISORY DEPARTMENT

OF

THE IMPERIAL COLLEGE OF

TROPICAL AGRICULTURE.

REPORT

ON THE

AGRICULTURAL DEPARTMENT, ST. VINCENT,

FOR THE YEAR

1934

IMPERIAL MYCOLOGICAL
11 MAY 1936
INSTITUTE

[Price Sixpence.]

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LETTER OF TRANSMITTAL.

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE,
AGRICULTURAL ADVISORY DEPARTMENT,
TRINIDAD,
5th September, 1935.

Ref. No. C.A. 1313/35.

SIR,—I have the honour to submit herewith the Annual Report of the Agricultural Department, St. Vincent, for the year ended December 31st, 1934.

2. The production of arrowroot, the principal crop of the Island, continues to rise both in volume and value as the following figures of exports indicate:—

	1932.	1933.	1934.
Quantity	3,704,833 lb.	4,589,435 lb.	6,526,003 lb.
Value	£47,524	£55,510	£75,044

3. Production figures for the same period are not given in the report and there is no indication as to stocks carried. As, however, the marketing of this product is entirely in the hands of a marketing Association, on which producers are well represented, the possibility of over production is constantly under review.

4. Increased production is due to two main factors; increased area and increased yields due to improved agricultural methods. Increased consumption is due to a far better demand for the product in the United States of America where exports have increased from two million pounds in 1931 to three and a half million pounds in 1934. There has also been a definite increase in consumption of arrowroot starch in Great Britain, Canada and Trinidad.

5. The report contains a detailed account of the results obtained by the research officer employed by the Association with special reference to the manuring of the crop. There are indications that an increasing number of producers are putting into practice the findings of this officer.

6. The syrup, sugar and rum industry exported in all £18,105 worth of produce in 1934 as compared with £21,261 in 1933 and £9,419 in 1932.

7. The Sea Island cotton industry is showing signs of recovery and the surplus accumulated stocks of cotton which for so long had a depressing effect on the market have now almost completely disappeared. It is expected that an increased area will be planted in this crop during future years.

8. St. Vincent with its Government owned cotton ginnery operating on a co-operative basis and having located in the Island a cotton research station responsible for the quality of the seed supplied to planters is extremely well placed to take advantage of any improvement in demand which may occur in the Sea Island cotton industry. Statements by officers of these two departments are included in the Report.

9. The land settlement scheme recently established at Three Rivers may now be regarded was well established. Your Honour's great interest and practical help in a great measure accounts for this satisfactory condition. The establishment of a credit society and the placing of the running of the arrowroot works in the hands of this society should prove a most interesting experiment.

10. Undoubtedly, the time has come to consider the extension of the principle of placing as large a number of people as possible on the land to other districts in the Island. The success achieved at Three Rivers is sufficient encouragement to proceed in this direction without further delay.

11. The fruit and vegetable industry in St. Vincent has not been of permanent value to the Island. With the increase in arrowroot production and the improved outlook for the Sea Island cotton industry, interest in the growing of fruit and vegetables has dwindled. Under the circumstances the recent decision of Government to close the Marketing Depôt was inevitable.

12. The re-organisation of the Agricultural Department following on the retirement of Mr. Jackson as Agricultural Superintendent promises to be of great benefit to the Island. The support and co-operation which it is receiving from the planting community is definitely encouraging.

I have the honour to be,

Sir,

Your obedient servant,

G. A. JONES,
Commissioner of Agriculture.

His Honour

THE ADMINISTRATOR,

St. Vincent, B.W.I.

(902/1935).

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Staff of the Agricultural Department, St. Vincent.

Acting Agricultural Superintendent (To July 15th) ...	P. Morrison.
Agricultural Superintendent (From July 16th) ...	A. K. Briant, M.A. Dip. Ag., (Cantab.), A.I.C.T.A.
Agricultural Assistant, Manager, Government Fruit and Vegetable Bureau, and Inspector, Agricultural Credit Societies (To August 30th) ...	P. Morrison.
Agricultural Assistant (From November 1st) ...	C. K. Robinson, D.I.C.T.A.
Cotton Inspector and Government Vaccinating Officer ...	L. Brown.
Foreman, Botanic and Experiment Stations ...	R. Vanloo.
Clerical Assistant	Miss D. E. Wall.
Laboratory Assistant to Cotton Research Officer ...	Miss N. Grant.
Officers in Training	F. A. DaCosta, (To November 30th and) S. B. Isaacs.

COTTON RESEARCH STATION.

Provided by the Empire Cotton Growing Corporation.

Cotton Research Officer	S. H. Evelyn, D.I.C.T.A.

REPORT ON THE AGRICULTURAL DEPARTMENT, ST. VINCENT.

FOR THE YEAR ENDED DECEMBER 31st, 1934.

Sections I, II and III of this Report were written by the Agricultural Superintendent; Section IV by the Cotton Research Officer, Section V by the Manager, Government Cotton Ginnery; and Section VI by the Biological Control Research Officer.

SECTION I.

Botanic Gardens.

During the last few years a shortage of funds has necessitated the expenditure on the Botanic Gardens being reduced to a minimum. Very little has therefore been done except to maintain them in a moderately clean condition. The Gardens are very well situated, and the large collection of palms and other economic and ornamental trees makes them very attractive. An increase in the proportion of flowering trees and shrubs, however, would considerably add to their beauty and to make this possible, a number of less important trees were removed at the end of the year.

The fern house which was in a very bad condition was repaired and painted.

As the result of a suggestion made by the Commissioner of Agriculture, the cocoa trees in the field at the east end of the Gardens were felled so that the land might be utilised for more useful purposes. The field is about two acres in extent and will probably be planted with citrus and bananas for demonstration and experimental purposes.

As it is thought that the previous site of the nursery in the Botanic Gardens is much more suitable for the production of young citrus plants than the present site at the Experiment Station, arrangements have been made to transfer the nursery back to the Gardens.

Plant Importations.

Twenty packets of seeds of ornamental plants were presented to the Botanic Gardens by Professor Juan Baume, Mexico, and collections of ornamental plants were received from the Departments of Agriculture in Barbados and Dominica.

Nurseries and Plant Distribution.

During the years 1932, 1933 and 1934 the following plants and propagating material have been distributed from the Experiment Station.

TABLE I.

			1932.	1933.	1934.
Plants.	Tomato	...	42,000	30,400	29,800
	Onion	...	1,000	1,300	2,800
	Cabbage	...	5,200	300	2,400
	Manila Hemp	...	810	—	—
	Lime grafted	...	347	1	4
	Mango ,,	...	257	418	195
	Grapefruit budded	...	76	345	99
	Orange ,,	...	44	181	5
	Avocado pears ,,	...	—	6	1
	Coconut	...	56	19	2
	Papaw	...	—	—	150
	Pineapple	...	75	172	22
	Decorative (Misc.)	...	1,387	182	139
	Economic ,,	...	86	58	—

			1932.	1933.	1934.
Cuttings.	Sugar-cane	...	16,500	26,050	12,300
	Sweet potato	...	1,200	8,800	—
	Aralia	...	3,000	—	—
Rhizomes.	Arrowroot	...	6,038 lb.	6,050 lb.	5,250 lb.
Seeds.	Groundnut	...	52 ,,	23 ,,	22 ,,
	Cover crops	...	—	10 ,,	320 ,,

As in previous years a supply of onion seed for distribution was imported from Teneriffe through the Commissioner of Agriculture. The demand for this seed was less than was expected and only $3\frac{1}{2}$ lb. of the 5 lb. ordered were sold. $5\frac{1}{4}$ lb. of tomato seed and 8 lb. of cabbage seed obtained from the United States of America were also distributed.

The number of grafted and budded citrus plants sold during 1934 was considerably less than in 1932 and 1933. Whether conditions in St. Vincent are suitable for citrus varieties is still open to doubt, and special efforts will be made during the next few years to produce relatively small quantities of first quality material for testing under different conditions. It is hoped that the establishment of the nursery at the Botanic Gardens where there is less exposure to wind will facilitate the production of better plants.

The top working of mango trees owned by private individuls was continued, and of the 379 trees cut back, 287 were budded successfully.

Inspection and Fumigation of Imported Plants and Seeds.

The following plants and plant material were examined and when necessary fumigated under the Importation of Plants Diseases Prevention Ordinance, 1906.

Vegetable and other Seeds	...	77	parcels
Ornamental and other Plants	...	22	,,

Two parcels of plant material were destroyed.

Insect Pests and Fungus Diseases.

Cotton Worm (*Alabama argillacea*) *Hubn.* During the 1934-35 cotton season not a single case of damage by cotton caterpillars was reported.

Cotton Stainer (*Dysdercus delauneyi*). Stainers are by far the most serious pest with which cotton growers at present have to contend. They are much more common in some districts on the windward side of the island than in others, and on the leeward side they are comparatively rare. During the season 1934-35 they appeared in great numbers in cotton fields in the north windward district as soon as the bolls began to mature, and a little later were very abundant in other windward districts The amount of stained cotton produced in the affected areas probably amounted to one third of the lint obtained. The high incidence of stainers in these areas is apparently due to their migration from forest lands where host plants, particularly *Sterculea caribaea* are abundant. At one time an attempt was made to eradicate the *Sterculea* trees in the Soufriere district, but it was soon realised that to complete the task would be uneconomic and probably impossible.

No host plants of the stainer were destroyed by the Department during 1934.

The number of stainers trapped and destroyed at the Experiment Station during the year were as follows :—

January	17,984	April	56,373	July	386	October	—
February	8,770	May	48,263	August	69	November	1,601
March	15,179	June	9,729	Sept.	—	December	639

Pink Bollworm (*Platyedra gossypiella*). Pink Bollworm was not recorded during the 1934-35 season until February 7th or 160 days after the first day of planting. Under existing circumstances this pest does very little damage and is usually rare unless plants are allowed to produce a second picking.

Arrowroot Leaf-roller (*Calpodes ethlius*). Very little damage was caused by arrowroot worms during the year. Weather conditions were apparently unfavourable for breeding.

Banana Borer (*Cosmopolites sordidus*). This pest has been recorded in St. Vincent but is apparently rare.

Cane Borer (*Diatraea saccharalis and D. canella*). These cane borers are both present in St. Vincent canes and grasses, but their incidence is apparently unusually low when compared with the incidence in the other islands of the Lesser Antilles.

Progress in Chief Industries.

Foreword.

The domestic exports from the Colony for the year 1934 were valued at £129,833, an increase of £17,568 over the corresponding figures for 1933. The value of arrowroot starch exported increased from £55,510 in 1933 to £75,044 in 1934 but the values of sugar, cocoa, copra and a few other articles were slightly less than in the previous year.

The total value of imports for the year 1934 was £163,035 an increase of £14,388 over the 1933 figures.

Reviewing the Colony as a whole there are definite signs that it is recovering from the effects of the world's economic depression.

The quantities and values of the principal exports from St. Vincent for the last three years are given in Table II.

TABLE II.

		Quantities exported.			Values exported.		
		1932.	1933.	1934.	1932.	1933.	1934.
					£	£	£
Arrowroot Starch	lbs.	3,704,833	4,589,435	6,526,003	47,524	55,510	75,044
Sugar	tons	200	850	750	1,900	8,162	5,979
Syrup & Molasses	gals.	164,040	278,528	269,233	5,994	11,624	11,218
Rum, proof	,,	10,169	9,832	5,761	1,525	1,475	908
Cotton, Sea Island	lbs.	148,860	160,792	204,519	8,392	8,107	9,346
Cotton, Marie Galante	,,	68,033	78,508	53,907	1,417	1,619	1,123
Copra	,,	2,227,631	2,149,641	2,015,675	11,426	8,978	6,551
Coconuts	no.	72,130	17,713	979,988	281	38	2,538
Cocoa	lbs.	84,679	100,230	94,758	1,332	1,141	894
Bananas	stems	401	431	458	51	37	46
Cassava Starch	lbs.	518,888	681,761	480,587	3,241	3,110	3,081
Groundnuts	,,	63,580	47,334	12,048	398	292	83
Nutmegs	,,	11,547	27,342	21,544	151	342	269
Mace	,,	2,737	6,015	5,044	139	301	210
Maize	,,	12,532	1,884	34,350	52	8	109
Peas	,,	87,265	120,658	60,274	545	754	377
Limes	no.	138,210	596,629	1,183,219	87	219	198
Plantains	stems	—	—	—	74	181	484
Sweet Potatoes	bags	7,507	7,909	9,868	1,101	2,186	3,152
Yams	lbs.	—	—	—	40	83	160
Tannias	,,	—	—	—	334	519	607
Cattle	no.	77	70	19	480	391	108
Goats	,,	2,377	2,642	2,372	846	873	633
Poultry	,,	—	—	—	401	820	770
Pigs	,,	2,068	2,637	2,174	3,481	3,422	3,705
Sheep	,,	505	756	800	262	408	438
Asses	,,	169	150	103	283	206	127
Horses	,,	20	7	9	234	223	333

Arrowroot.

During 1934 the production of arrowroot starch in St. Vincent reached a new high record. The steady demand for arrowroot starch during the few years prior to 1934 and the existence of large stocks of Sea Island cotton unsold resulted in the acreage under arrowroot being increased. Further, owing to an improvement in the methods of cultivation and manuring larger yields per acre have been obtained. In the first quarter of 1934 there was some doubt as to whether there should not be some slight restriction of production, as a safeguard against the accumulation of stocks. The improved demand for starch during the latter part of the year, however, notably from the United States of America, has effected a considerable improvement in the prospects of the industry, and the consideration of restriction has been postponed.

The exports of arrowroot starch for the year amounted to 6,526,003 lb. valued at £75,044, of which quantity more than half was shipped to the United States of America. The quantities shipped to the various countries during the last six years, and the total exports and values for the last ten years are given in Tables III and IV. It will be seen that the exports to the United Kingdom, the United States, Canada and Trinidad have increased considerably when compared with the corresponding figures for 1933.

TABLE III.

Countries.	1929.	1930.	1931.	1932.	1933.	1934.
United Kingdom ...	1,529,599	1,496,330	1,017,193	1,122,621	1,523,663	1,794,125
U. S. America ...	1,078,093	1,084,536	1,980,809	2,036,728	2,455,858	3,534,071
France ...	121,401	58,741	31,115	106,415	230,160	142,410
Canada ...	206,396	255,083	246,956	258,497	193,557	370,838
Barbados ...	364,411	378,441	38,945	11,877	8,492	98,748
Germany ...	76,576	60,322	13,920	47,358	78,814	63,628
Trinidad ...	72,392	31,856	27,479	873	6,720	384,188
Holland ...	48,541	138,356	112,311	80,413	51,520	36,739
Antigua ...	20,810	14,941	24,937	8,212	5,835	15,024
Jamaica ...	4,704	7,083	16,026	12,077	12,000	2,400
British Guiana ...	...	...	...	...	...	52,720
Curaçao ...	...	...	...	...	..	15,000
Other Countries ...	50,836	64,659	22,636	19,762	22,816	16,112

TABLE IV.

Year.	Arrowroot. lb.	Value. £	Cassava. lb.	Value. £.
1925	3,190,412	53,174	470,284	4,160
1926	3,291,553	45,807	443,075	4,077
1927	3,195,487	53,309	543,681	4,904
1928	3,870,420	64,508	392,610	3,272
1929	3,573,759	59,563	551,512	4,595
1930	3,590,348	59,019	562,327	4,688
1931	3,532,327	44,915	587,071	3,662
1932	3,704,833	47,524	518,888	3,241
1933	4,589,435	55,510	681,761	3,110
1934	6,526,003	75,044	480,587	3,081

Planters are now paying much more attention to producing starch of a higher grade.

During the last two years Mr. C. K Robinson, Scientific Officer to the St. Vincent Co-operative Arrowroot Association, has conducted several experiments on various arrowroot problems, and there is no doubt that the results he has obtained are already benefiting many growers throughout the island. With the permission of the Board of the Association, a Report by Mr. Robinson on the experiments he has conducted is published below.

Manurial Experiments on Arrowroot.

Previous Work. The earliest arrowroot manurial experiments on record are two series of trials laid down by the Department of Agriculture in 1913 at the Experiment Station and at Spring Estate and recorded in the Annual Report of the Department for 1913—14, (1), (2).

The trial at the Experiment Station consisted of three treatments: 1 Control. 2. Sulphate of potash (1 cwt.). 3. Sulphate of potash (2 cwt.) and basic phosphate (4 cwt.) in two series.

The mean of the results showed a loss of 1,950 lb. per acre of rhizomes from the sulphate of potash and the gain of 1,620 lb. per acre from the sulphate of potash and basic phosphate. As there were only two replicates of each treatment, however, not much significance can be attached to these results.

The Spring Estate experiment was much more elaborate but, unfortunately, the plots were so badly damaged by storm-water that the experiment was abandoned.

Following these inconclusive trials, the next experiments were laid down by Harland in 1916—17 at the Experiment Station (3). These experiments were continued for three seasons till 1919.

A. To test the value of mulching with prunings of Gliricidia maculata.

There were twelve plots in this experiment each $\frac{1}{138}$ acre in area, of which four were mulched with 40 lb. of *Gliricidia* prunings per plot and eight left as controls.

In 1916—17 the mean of the differences in favour of mulching was 4,142 lb. per acre and the value of t was calculated to be 3,964. According to Fisher's table of t, such a value would occur by chance rather less than once in one hundred trials. The increase of 4,142 lb. of rhizomes per acre or 43·3 per cent is, therefore, highly significant.

Similar results were obtained in 1917—18 (4) and 1918—19 (5). In fact, Harland claims to have obtained increases of over 200 per cent in both these years. There can be no doubt, therefore, that mulching with *Gliricidia* prunings does result in a large increase in yield of rhizomes. The action of the *Gliricidia* mulch will be discussed in greater detail later.

B. To compare the relative values of various combinations of organic and artificial fertilizers.

Nine different combinations of manures were applied to thirty-six plots divided into four series of nine plots each, each treatment occurring once in each series. The treatments were as follows: (1) control, (2) sulphate of ammonia (30 lb. N per acre), (3) basic slag (40 lb. P_2O_5 per acre), (4) sulphate of potash, (30 lb. K_2O per acre), (5) basic slag and sulphate of potash, (6) sulphate of ammonia, basic slag and sulphate of potash, (7) cotton seed meal (600 lb. per acre), (8) basic slag, sulphate of potash and cotton seed meal, (9) *Gliricidia* prunings.

Harland (6) concluded from these experiments that there was deficiency of potash in St. Vincent soils: "The part played by potash in the nutrition of the arrowroot plant under the soil conditions of St. Vincent seems to be as important as cotton . . . . . On the whole, all the evidence from both the cotton and arrowroot experiments is in favour of the view that St. Vincent soils are deficient in potash".

Harland's experimental results have since been subjected to detailed statistical analysis by methods which have only recently become available. The experiments were regarded as being laid out in the form of randomised blocks and treated by the methods appropriate to this type of design. This assumption may not be entirely justified but it permits the application of more stringent tests in the examination of the experimental data, thereby increasing the reliability of any conclusions that may be deducted. This analysis indicates that no significance can be attached to the differences of yield between the various treatments, excluding the *Gliricidia* treatment, and that Harland's conclusions with respect to potash deficiency cannot be supported by the experimental data.

Dr. E. J. Maskell (7) subjected the data of Harland's cotton manurial experiments to statistical analysis and concluded that "only relatively large differences in response to particular treatments in different years would be detected with any accuracy".

The next series of manurial experiments were laid down by Jackson (8) in 1931 and 1932. There were ten different treatments in 1931, each repeated three times and apparently distributed at random over the whole experimental area. Unfortunately this form of distribution, while allowing a valid estimate of experimental error to be made, tends to an unnecessarily high value of the latter owing to soil differences which could have been partially eliminated by a controlled randomised distribution of treatments. Consequently only large differences in yield between treatments could be proved significant.

Jackson's ten treatments were as follows : (1) control, (2) nitrogen (30 lb. N. per acre) as sulphate of ammonia, (3) Phosphate (40 lb. P_2O_5 per acre) as basic slag, (4) potash (30 lb. K_2O per acre) as sulphate of potash, (5) phosphate and potash, (6) nitrogen, phosphate and potash, (7) cotton seed meal (600 lb. per acre), (8) phosphate, potash and cotton seed meal, (9) pen manure (10 tons per acre) and, (10) *Gliricidia* prunings mulch.

On analysis, it was found that treatment had had a highly significant effect on yield. It was determined, however, that only *Gliricidia* and pen manure produced yields that were significantly greater than the controls and that the differences due to the other treatments were such that they could have occurred by chance too frequently to be significant.

In 1932 (9) similar results were obtained. The dressings of pen manure and cotton seed meal were increased to 20 tons per acre and 1000 lb. per acre respectively, and another treatment, stained cotton seed meal (1000 lb. per acre) was included in the experiment. *Gliricidia*, pen manure and stained cotton seed meal gave yields significantly better than the controls. The yields from the plots mulched with *Gliricidia* was significantly better than that from the stained cotton seed meal plots but not better than that from the plots receiving pen manure. The yields from the other treatments were not significantly greater than the controls.

When the results of all these experiments are reviewed one definite fact emerges : manurial treatments involving the addition of organic matter, particularly as a mulch, result in large increases in yield. No definite conclusions can be drawn with regard to the artificial fertilizers, as, in general, the lay out adopted for these experiments was such that variation between replicates completely masked the effect of treatment, unless the differences between treatments were very large. There are indications, however, that artificials under the conditions of the above experiments, did not have such pronounced effects as organic matter.

Recent Work. A new series of experiments was commenced by the writer in 1933.

I. Mulching Experiments. As both Harland and Jackson had obtained definite proofs of the effect of mulching with *Gliricidia*, it was taken as conclusively established that this treatment had a beneficial effect on yield.

The precise mechanism of this action, however, was not by any means clear and it seemed to have been assumed that the effect was peculiar to *Gliricidia*. As there was no apparent reason why this should be so, an experiment (10) was laid down to compare the effect of various mulches. The treatments used were (1) Bengal beans (*Stizolobium* sp.), (2) Sword beans (*Canavalia* sp.), (3) *Gliricidia maculata*, (4) *Hibiscus Rosa-sinensis*, (5) Control.

The results showed that all mulches produced yields significantly greater than the control, the average increase in yields being 26 per cent. There was, however, no significant difference between the various mulches. This indicates that the beneficial effect is common to any young green vegetable matter applied as a mulch. The possible actions of a mulch include :—

1. Conservation of soil moisture. This effect can be entirely disregarded as in all cases the mulches were applied during the rainy season.

2. Increased retention of plant nutrients by increasing the humus content of the soil. Hardy, Robinson and Rodriguez (11) have shown that there is a higher exchangeable base content in the surface layer of St. Vincent soils but that the magnitude of the effect due to colloidal humus is small. The amount of humus added by mulching is practically negligible.

3. The effect of carbon dioxide liberated by the oxidation of plant tissues. Hardy, Robinson and Rodriguez (loc. cit.) found that the electrical conductivity of soil extracts was considerably augmented by increasing the carbon dioxide content of the water. It has been suggested by these authors, therefore, that decaying organic matter may accelerate the rate of production of available plant nutrients in the fresh mineral sandy soils of St. Vincent.

4. Increased activity of soil micro-organisms and the generation of growth promoting substances or "auximones" by the decomposition of organic matter by micro-organisms.

5. The liberation of plant nutrients from the decaying plant tissues. While some or all of the above effects may play some part in increasing the yield as a result of mulching, it appears highly probable that the most important effect of a mulch under these conditions is the liberation of plant nutrients and more especially of available nitrogen. This aspect of the question will be considered later in the light of the results of the manurial experiments now to be described.

II. Manurial Experiments—1933-34.

The soils of St. Vincent may be divided into three major classes (11) :

I. Yellow earth soils (agglomerate, ash and lava soils)
II. Alluvial soils (chiefly volcanic sand washed down from the slopes)
III. Recent volcanic ash soils (volcanic ash and sand deposited by recent eruptions of the Soufriere).

As arrowroot is grown on all these major soil types an attempt was made to lay out the experiments on sites representative of these types. The soil profile data of the types chosen are reproduced in Table V from "Agricultural Soils of St. Vincent" by Hardy, Robinson and Rodriguez.

As may be seen from the soil profile data given the soils chosen were sandy with a low organic matter content (in general this is characteristic of St. Vincent soils). It was thought desirable, therefore, to incorporate a basal dressing of pen manure in the manurial treatments.

1. Control.
2. Pen manure (10 tons per acre).
3. Pen manure (10 tons per acre) + sulphate of ammonia (300 lb. per acre).
4. Pen manure (10 tons per acre) + sulphate of potash (180 lb. per acre).
5. Pen manure (10 tons per acre) + superphosphate (270 lb. per acre).
6. Sulphate of ammonia (300 lb. per acre) + sulphate of potash (180 lb. per acre) + superphosphate (270 lb. per acre).

TABLE V.

	Lower Depth (ins.)	Gravel %	Coarse sand. %	Fine sand %	Silt and Clay. %	Normal pH.	O. M. %	N. %	C/N. Ratio.	Avail. Nutri-ents.	Rate of Soln.	Phos-phate p. p. m.	Potash p. p. m.
I *Montrose Estate* ...	6	0	44	30	26	6·5	1·79	0·13	8·3	87	56	17	142
Yellow earth ...	12	0	39	32	29	6·6	1·24	0·09	7.6	74	58		75
(Low level) ...	18	0	36	33	31	6·7	0·86	0·06	7·8	69	37		
Grassy weedy land after cotton ...	24	0	36	32	32	6·8	0·74	0·05	8·6	54	40		
II *Diamond Estate* ...	6	3	29	33	38	6·6	1·40	0·10	8·6	142	62	55	235
Valley alluvium soil ...	12	3	26	33	41	7·0	0·93	0·07	7·3	94	47	13	92
Coastal valley type ...	18	5	26	36	38	7·1	0·64	0·05	7·8	66	40		
Grassy herbaceous weeds, poor soil ...	24	12	30	34	36	7·2	0·58	0·04	7·7	62	38		
III *Keartons Estate* ...	6	11	56	22	22	6·5	1·40	0·09	9·4	78	41	196	210
Valley alluvium soil ...	12	13	58	20	22	6.5	1·40	0·08	9·8	68	56	234	177
Coastal valley type ...	18	18	54	23	23	6·6	1·09	0·07	9·3	67	51		
Flat at base of hills Cotton land ; loose ash ...	24	11	57	21	22	6·7	0·93	0·06	9·6	69	27		
IV *Grand Sable Estate* ...	6	26	80	12	8	6·6	1·29	0·07	10·5	73	34	156	123
Recent volcanic ash ...	12	28	78	11	11	6·7	0·73	0·04	10·1	41	25	102	94
Scrub and grass flora ...	18	29	75	13	12	6·5	0·86	0·05	10·9	44	19		
Flat at foot of hills ...	24	31	69	16	15	6·5	0·96	0·06	9·9	56	23		

Lay-out. The experimental lay-out adopted was a 6 x 6 Latin square, each plot being 17 ft. x 51·1 ft. and having a three feet border to reduce the interaction of adjacent plots.

Cultivation and Manuring. The experimental plots were all hoe-ploughed and the pen manure ploughed in on the appropriate plots. The plots were then planted on the following dates: Montrose 17/5/33, Diamond 18/5/33, Keartons 29/5/33 and Grand Sable 10/8/33. The artificial fertilizers were applied just as the plants were entering the flowering stage, *i.e.*, when the plants were about four months old: Montrose 5/9/33, Diamond 16/9/33, Keartons 25/9/33 and Grand Sable 15/10/33. No information was available as to the most suitable time of application but later work indicates that the times chosen were very near the optimum. This will be discussed later. The experimental plots were treated exactly as normal estate fields, weeded when necessary and given no special treatment except the manurial treatments mentioned above.

Yields. The experiments were reaped on the following dates: Montrose 20/4/34, Diamond 27/4/34, Keartons 4/5/34 and Grand Sable 11/5/34. The lay-out of the experiments and the yields obtained are shown diagramatically in Table VI. The yields are given in lb. per plot and the numbers in brackets are the treatment numbers as given above.

TABLE VI.

Montrose.

(3)	(4)	(6)	(5)	(2)	(1)
441	413	436	424	321	408
(1)	(5)	(2)	(3)	(6)	(4)
369	386	375	520	409	262
(2)	(6)	(1)	(4)	(5)	(3)
336	425	325	463	328	449
(6)	(3)	(5)	(1)	(4)	(2)
419	431	328	307	383	444
(4)	(2)	(3)	(6)	(1)	(5)
283	352	382	369	347	421
(5)	(1)	(4)	(2)	(3)	(6)
288	292	325	370	452	441

Diamond.

(4)	(5)	(1)	(3)	(6)	(2)
217	241	178	326	357	249
(6)	(3)	(2)	(4)	(1)	(5)
304	317	251	265	180	283
(3)	(2)	(4)	(1)	(5)	(6)
315	275	231	172	285	332
(5)	(6)	(3)	(2)	(4)	(1)
246	247	285	235	336	280
(2)	(1)	(6)	(5)	(3)	(4)
247	154	278	256	308	226
(1)	(4)	(5)	(6)	(2)	(3)
199	186	197	253	237	312

Keartons.

(6)	(3)	(4)	(1)	(5)	(2)
135	155	77	103	74	80
(1)	(2)	(5)	(4)	(3)	(6)
116	121	83	90	100	95
(5)	(4)	(3)	(6)	(2)	(1)
149	129	163	97	56	90
(2)	(6)	(1)	(3)	(4)	(5)
152	114	67	107	79	81
(3)	(1)	(2)	(5)	(6)	(4)
210	131	126	95	129	124
(4)	(5)	(6)	(2)	(1)	(3)
214	211	245	172	131	160

Grand Sable.

(3)	(1)	(4)	(6)	(2)	(5)
269	255	267	280	280	275
(5)	(6)	(3)	(2)	(4)	(1)
219	273	264	224	226	208
(2)	(4)	(5)	(1)	(3)	(6)
147	166	190	181	236	226
(4)	(5)	(1)	(3)	(6)	(2)
156	146	172	199	216	161
(6)	(3)	(2)	(5)	(1)	(4)
200	196	157	175	132	158
(1)	(2)	(6)	(4)	(5)	(3)
122	71	143	122	127	131

The treatment totals in lb. for all the experiments are given in Table VII.

TABLE VII.

Treatment.	Montrose.	Diamond.	Keartons.	Grand Sable.	Total.	% Increase over control.
1. Control ...	2,048	1,163	633	1,070	4,919	
2. Pen manure ...	2,198	1,494	707	1,040	5,439	10·6
3. Pen manure + sulphate of ammonia ...	2,675	1,863	895	1,295	6,728	36·8
4. Pen manure + sulphate of potash ...	2,139	1,461	713	1,095	5,408	9.9
5. Pen manure + superphosphate ...	2,175	1,508	693	1,132	5,508	12·0
6. Sulphate of ammonia + superphosphate + sulphate of potash	2,499	1,771	815	1,338	6,423	30·6

The analysis of variance is given in Table VIII.

TABLE VIII.

Due to	Degrees Freedom.	Sum Squares.	Variance.	½ log e Variance.	Z.
Rows ...	20	138,560			
Columns ...	20	48,211			
Squares ...	3	23,100	7,700·0	1·021	0·987
Treatments ...	5	98,970	19,794·0	1·492	1·458
Interaction (Treatment x Square)	15	21,949	1,461·3	0·189	0·155
Error ...	80	85,605	1,070·1	0·034	
Total ...	143	416,395			

The following values of Z were obtained from Fisher's Tables:

1. Squares : $N_1 = 3$, $N_2 = 80$ and $P = \cdot 01$, $Z = 0 \cdot 7086$.
2. Treatments : $N_1 = 5$, $N_2 = 80$ and $P = \cdot 01$, $Z = 0 \cdot 6028$.
3. Interaction : $N_1 = 15$, $N_2 = 80$ and $P = \cdot 05$, $Z = 0 \cdot 3255$.

From the figures given in Table VIII it will be seen that :—

1. Treatment exerted a highly significant effect on yield.
2. Locality had a very decidedly significant effect on yield. It is apparent from the square totals that the sites chosen varied considerably in fertility.
3. There was no significant differential action of the effect of treatment on yield due to locality.

Effect of the various manurial treatments. In order that a difference between two treatment totals may be significant it has been calculated that it must be greater than 443·9 lb. Using this standard the following conclusions may be drawn.

1. All treatments produced yields significantly greater than the controls.
2. No significance can be attached to the small differences in yield between the plots treated with pen-manure, pen-manure + sulphate of potash, and pen-manure + superphosphate as they could easily have been due to chance. This indicates that, under the conditions of the experiments the soils' requirements of potash and superphosphate, if such exist, with respect to the arrowroot crop, were met by the quantities of the above nutrients contained in the pen-manure.
3. The yields obtained from treatments of pen-manure + sulphate of ammonia and from the complete artificial fertilizer were significantly greater than from the other treatments. This indicates that the chief deficiency in St. Vincent soils, in so far as the arrowroot plant is concerned, is *Nitrogen*.

From the fact that the yield from the complete artificial is less than that from the pen-manure + sulphate of ammonia, (though not significantly so), it would seem reasonable to conclude that the indicated superiority of this latter treatment is due to the provision of a greater supply of available nitrogen, possibly by increasing nitrogen conservation.

III. Manurial Experiments 1934-35.

The same treatments were applied to the same experimental plots as in the previous year as it was thought desirable (1) to confirm the previous year's work and (2) to determine the effect of season on manurial response.

As is customary, the plots were replanted when the 1933-34 experiments were reaped, the "heads" of the rhizomes being simply broken off and buried. The pen-manure was applied to the appropriate plots at the same time. The artificial fertilizers were broadcast on the following dates. Montrose 16/6/34, Diamond 16/7/34, Keartons 23/7/34, Grand Sable 20/7/34. The experimental plots were again treated in the usual estate manner, that is, the thin spots were supplied and the plots weeded when necessary. There was no departure from routine practice.

The experiments were reaped on the following dates. Montrose 16/2/35, Diamond 13/3/35, Keartons 27/2/35, Grand Sable 16/4/35. The yields obtained in lbs. per acre are given in Table IX, and in lb. per treatment in Table X.

TABLE IX.

Montrose.

(3)	(4)	(6)	(5)	(2)	(1)
647	521	586	505	597	552
(1)	(5)	(2)	(3)	(6)	(4)
486	496	487	613	579	540
(2)	(6)	(1)	(4)	(5)	(3)
487	590	493	479	545	630
(6)	(3)	(5)	(1)	(4)	(2)
540	501	595	418	583	568
(4)	(2)	(3)	(6)	(1)	(5)
422	480	584	515	522	598
(5)	(1)	(4)	(2)	(3)	(6)
372	281	374	496	518	561

Diamond.

(4)	(5)	(1)	(3)	(6)	(2)
345	394	244	421	356	356
(6)	(3)	(2)	(4)	(1)	(5)
345	372	362	269	266	312
(3)	(2)	(4)	(1)	(5)	(6)
461	446	407	301	377	331
(5)	(6)	(3)	(2)	(4)	(1)
381	436	474	396	326	324
(2)	(1)	(6)	(5)	(3)	(4)
372	297	516	410	389	286
(1)	(4)	(5)	(6)	(2)	(3)
254	366	438	430	354	434

Keartons.

(6)	(3)	(4)	(1)	(5)	(2)
343	382	273	206	316	304
(1)	(2)	(5)	(4)	(3)	(6)
331	345	380	305	429	356
(5)	(4)	(3)	(6)	(2)	(1)
438	366	418	331	410	249
(2)	(6)	(1)	(3)	(4)	(5)
408	350	291	445	363	438
(3)	(1)	(2)	(5)	(6)	(4)
474	378	372	377	424	393
(4)	(5)	(6)	(2)	(1)	(3)
496	434	425	435	358	528

Grand Sable.

(3)	(1)	(4)	(6)	(2)	(5)
406	384	476	528	614	528
(5)	(6)	(3)	(2)	(4)	(1)
363	393	431	404	427	259
(2)	(4)	(5)	(1)	(3)	(6)
320	330	384	311	486	410
(4)	(5)	(1)	(3)	(6)	(2)
277	277	266	462	503	372
(6)	(3)	(2)	(5)	(1)	(4)
399	433	382	409	327	349
(1)	(2)	(6)	(4)	(5)	(3)
247	310	413	335	377	464

TABLE X.

Treatment.	Montrose.	Diamond.	Keartons.	Grand Sable.	Total.	% Increase over control.
1. Control ...	2,752	1,686	1,813	1,794	8,045	
2. Pen-manure ...	3,115	2,286	2,274	2,402	10,077	25·2
3. Pen-manure + sulphate of ammonia	3,493	2,551	2,676	2,682	11,402	41·7
4. Pen-manure + sulphate of potash ...	2,919	1,999	2,196	2,194	9,308	15·7
5. Pen-manure + superphosphate ...	3,111	2,312	2,383	2,338	10,144	26·1
6. Sulphate of ammonia + superphosphate + sulphate of potash ...	3,371	2,414	2,229	2,646	10,660	32·5

The analysis of variance is given in Table XI. From this table it will be seen that treatment again had a highly significant effect on yield and that there was no differential effect due to locality.

TABLE XI.

Due to	Degrees Freedom.	Sum Squares.	Variance	$\frac{1}{2}$ log e Variance	Z.
Rows ...	20	171,825			
Columns ...	20	182,544			
Squares ...	3	20,768	6,922·6	0·9674	0·7904
Treatments ...	5	279,452	55,890·4	2·0100	1·8330
Interaction (Treatment x square)	15	20,214	1,347·6		
Error ...	80	137,436	1,424·9	0·1770	
Total ...	143	783,800			

From Fisher's Tables the following values were obtained:—

1. Squares: $N_1 = 3$, $N_2 = 80$ and $P = \cdot 01$, $Z = 0 \cdot 7086$.
2. Treatments: $N_1 = 5$, $N_2 = 80$ and $P = \cdot 01$, $Z = 0 \cdot 6028$
3. Interaction: $N_1 = 80$, $N_2 = 15$ and $P = \cdot 05$, $Z = 0 \cdot 3628$

It has been calculated that a difference between any two treatment totals greater than 456·8 lb. is significant. It is concluded, therefore, that—

1. All treatments were significantly better than the control.
2. Pen-manure + sulphate of ammonia and the complete fertilizer were again significantly better than any other treatment.
3. Pen-manure + sulphate of ammonia produced yields that were significantly better than the complete artificial fertilizer.
4. Again there was no significant difference between the yields from pen-manure and pen-manure + superphosphate.

5. The yields from the pen-manure were significantly better than those from the pen-manure + sulphate of potash. In view of the important rôle potassium plays in the manufacture of starch this result is surprising as it indicates that the addition of potash to pen-manure actually depresses the yield. There were indications of such an action in the 1933-34 experiment but the difference was not significant.

With the exception that pen-manure + sulphate of potash produced yields which were significantly less than those from pen-manure alone, these results are in complete agreement with those obtained in the previous year. Before discussing this experiment in detail, however, the results of a "Time of Application" experiment will be described.

IV. "Time of Application" Experiment.

This experiment was laid down to determine the optimum time of application of artificial fertilizers to arrowroot. There was no information available on this point and it was thought desirable to obtain the information before drawing definite conclusions especially with respect to the response to potash and phosphate. It is generally held that plants absorb most of the potash and phosphate they require in their early stages of growth, whereas in the recent manurial experiment described above, the artificial fertilizers were not applied until the arrowroot plants were at least two months old. It was possible, therefore, that the poor response to potash and phosphate may have been due to application at the wrong time. The treatments were as follows :—

1. Complete artificials (N.P.K.) at planting (9/7/34).
2. Complete artificials two months after planting (17/9/34).
3. Complete artificials at flowering (16/11/34).
4. Phosphate and potash at planting (9/7/34) and nitrogen two months later (17/9/34).
5. Phosphate and potash at planting (9/7/34) and nitrogen at flowering (16/11/34).

The rates of application were : sulphate of ammonia 300 lb. per acre, sulphate of potash 180 lb. per acre and superphosphate 270 lb. per acre.

The lay out adopted was a 5 x 5 Latin square with plots 18 ft. by 32 ft. ($\frac{1}{75}$ acre approximately).

The experiment was reaped on 6/4/35 and the treatments (in brackets) and the yields, in lb. per plot, are given in Table XII. The mean yields of the various treatments, and the analysis of variance are given in Tables XIII and XIV respectively.

TABLE XII.

(1)	(5)	(4)	(3)	(2)
272	332	330	326	330
(4)	(2)	(1)	(5)	(3)
307	328	230	302	345
(2)	(1)	(3)	(4)	(5)
318	235	309	334	339
(3)	(4)	(5)	(2)	(1)
338	323	306	308	251
(5)	(3)	(2)	(1)	(4)
306	325	337	316	330

TABLE XIII.

Treatments.	Yields in lb. Mean of 5 plots.
1. N.P.K. (9/7/34) ...	261
2. N.P.K. (17/9/34) ...	330
3. N.P.K. (16/11/34) ...	329
4. P.K. (9/7/34), N (17/9/34) ...	325
5. P.K. (9/7/34). N (16/11/34)...	317

TABLE XIV.

Due to	Degrees Freedom.	Sum Squares.	Variance.	½ log e Variance.
Rows ...	4	1,458		
Columns ...	4	921		
Treatment ...	4	17,083	4,270·75	1·876
Error ...	12	8,065	672·08	0·9523
Total ...	24	27,527		Z = 0·9237

From Fisher's Tables, for $N_1=4$, $N_2=12$ and $P=·01$, $Z=0·8443$.

Time of application, therefore, undoubtedly had a significant effect on yield, under the conditions of this experiment. In order that a difference between two means may be significant it must be equal to, or greater than 32·63 lb. It may be seen, therefore, that:

1. The yields obtained from treatment (1) in N.P.K. applied at the time of planting were significant less than those from any other treatment.
2. There is no significant difference between the yields of the other treatments.

Under the conditions of this experiment, therefore, the time of application of potash and phosphate did not materially affect the yields obtained. The time of application of sulphate of ammonia, however, had a very important effect on yield. The application of this fertilizer when the plants were between two and four months old resulted in an increase of 22—26 per cent. over the application at the time of planting.

In view of the sandy nature of St. Vincent soils with their very low content of colloidal matter, and the high rainfall during the wet season such a result is not surprising. Nitrogen applied at an early stage in the growth of the plants can only be taken up very slowly by the very small absorbing root system then developed, and, as there is practically no colloidal matter to adsorb the nitrogen there is likely to be a considerable loss through leaching. This effect would probably be more marked on a hillside with freer drainage.

Discussion. The evidence of all the experiments quoted above definitely indicates that lack of nitrogen is the limiting factor in crop production in St. Vincent, at any rate, in so far as the arrowroot crop is concerned. There is reason to believe, moreover, that this statement could be applied to other crops grown in the island. The cotton manurial experiment conducted during the past season and recorded elsewhere in this Report showed that considerable increases in seed cotton and lint were produced by applications of nitrogen. Further, as a result of general observations on other crops one is led to conclude that they also show signs of nitrogen starvation.

As this deficiency of nitrogen appears to be general for the different soil types and apparently for all crops, it seems that it is a fundamental character of the soil-climate complex of the island.

The soils of St. Vincent are chiefly derived from loose volcanic agglomerates (11), the weathering of which results in soils with indices of texture varying from 2—18, signifying very sandy soils which are largely composed of unweathered mineral grains. Their organic matter content is moderately low (1·82 per cent as compared with 2·80 per cent in Grenada soils) and further their carbon-nitrogen ratio is higher than in Grenada soils (8·3 as against 7·4) which means that not only is the organic matter content lower but that it is in a less humified condition, and consequently there is less available nitrogen.

The nitrogen content of St. Vincent soils is not only intrinsically low but it would also be a matter of great difficulty to effect any permanent material increase in the organic matter content, and consequently in the nitrogen content. With an average rainfall for the island of about 100 inches and a mean temperature ranging from 76°—82°F. biological activity in these light sandy soils probably proceeds at a very high rate. Under such conditions organic matter added to the soil would be rapidly and completely decomposed within the course of a few months with the liberation of nitrogen and carbon dioxide and the accumulation of humus would be reduced to a minimum. (12), (13), (14).

In such soils there is little or no conservation of nitrogen and the rate at which it becomes available would undoubtedly have a very important effect on the crop response. A manure like sulphate of ammonia contains its nitrogen in the very soluble ammonium form or is converted in a very short time to the equally soluble nitrate form. In either case, nitrogen is very rapidly available and unless quickly assimilated by the crop is liable to be lost. For instance, in the "Time of Application" experiment mentioned above, the addition of sulphate of ammonia at the time of planting was much less beneficial than the later applications and this can be most satisfactorily explained as being due to loss of nitrogen through leaching. There are also indications that the failure of Harland and Jackson to obtain conclusive results from sulphate of ammonia treatments was due to this cause. From the scanty records available it would appear that all manures were applied either at the time of planting or soon after. It is evident, therefore, that sulphate of ammonia should only be applied when the plants have grown sufficiently to assimilate quickly the rapidly produced nitrogen, *i.e.*, when from two to four months old. Further, periods of heavy rainfall should be avoided, as a heavy shower directly after application may result in an almost complete loss of the fertilizer.

This leads to the very important question of the type of nitrogen producing fertilizer best suited to St. Vincent conditions. It is likely that a less soluble fertilizer in which the nitrogen is made available more slowly would give higher returns, per unit of nitrogen, than sulphate of ammonia. With this end in view experiments will be conducted to compare other nitrogen fertilizers with sulphate of ammonia.

It is now possible to obtain a clearer conception of the probable action of the mulch. Basing the yields on the experimental results described above calculation shows that the response to mulching is considerably greater than would be obtained from a complete artificial fertilizer of the same chemical composition. As previously mentioned a considerable increase in the supply of nutrients as measured by electrical conductivity, could be obtained by the addition of carbon dioxide to soil water and, of course, a large volume of carbon dioxide would be liberated during the decomposition of the mulch. The chief nutrients so affected, however, would be the potash and phosphate and, as the response to these elements was relatively small in the field experiments, it appears that such an effect is only of secondary importance. A much more satisfactory explanation is the relatively slow rate at which the nitrogen liberated from the tissues of the mulch would become available. The production of nitrogen in the form of nitrates is the result of a chain of reactions dependent on microbial activities chiefly in the lower humidified layer of mulch in contact with the soil (15), so that the supply when compared with that derived from sulphate of ammonia, is of a slow steady nature, ideally suited to plant nutrition as plant metabolism requires a small but constant supply of nutrients. The losses from leaching would be very low and a highly efficient utilisation of the nitrogen by the plant would be possible. It is suggested that the large increases in yield obtained by Harland and Jackson as a result of mulching could be explained in this way.

Pen-manure. From the yield figures it would appear that the action of pen-manure is very different from that of a mulch. In 1933–34 the average increase in yield from pen-manure was 10·6 per cent., whereas in 1934-35, the increase was 25·2 per cent. Superficially, this seems to indicate a relatively slight effect in the year of application with a considerable residual effect. There is, however, the possibility that the quality of the pen-manure was responsible for the differences in yield between the two years. Pen-manure in St. Vincent is prepared with a maximum amount of litter and a minimum number of oxen, and as it is made in open pens rainfall may have a very important effect on the quality. Unfortunately it was not possible to obtain analyses of the pen-manure used in these experiments but from casual inspections it appeared that the pen-manure used in the second year was more mature and of superior quality. The comparative yields are shown in Table XV, expressed as percentage increases over the controls.

TABLE XV.

	Montrose.	Diamond.	Keartons.	Grand Sable.	Average.
1933–34 ...	7·3 %	28·4 %	10·8 %	−2·8 %	10·6 %
1934–35 ...	13·2 %	35·6 %	26·5 %	33·9 %	25·2 %

Not only was the level of response higher in 1934-35 but the range of variation was considerably reduced and, but for the Montrose figure, is relatively small. It is possible, therefore, that the better quality of pen-manure was responsible for the more consistent results.

In the manurial experiments recorded by Jackson (8), (9), the increase in yield from an application of 20 tons of pen-manure in 1932 was 48 per cent. or slightly more than double the 23 per cent. increase obtained by applying 10 tons in 1931. The increase in yield of 23 per cent. is remarkably close to the average of 25 per cent. obtained by the same application in 1934-35.

The above facts are certainly not suggestive of a residual effect of any great magnitude. It is hoped that further information as to the presence or absence of a residual effect will be obtained by continuing the experiments during 1935-36 with the omission of pen-manure.

The decidedly low response obtained at Montrose in 1934-35 is unlikely to have been due to poor quality as the manure was obtained from a closed pen and was apparently quite good. The general yield level in this experiment was very high and the response to all treatments was relatively low. This can probably be explained by the high nitrogen content and the low potash/nitrate ratio of the top 12 inches of soil. The potash/nitrate ratios of the experimental fields are as follows. ((11) p. 17).

Montrose.	Diamond.	Keartons.	Grand Sable.
2·2	5·9	8·1	5·4

Pen-manure plus sulphate of potash. The addition of potash plus pen-manure resulted in a significant decrease in yield as compared with pen-manure alone, the effect being particularly marked in 1934-35 when the average relative decrease was 7·6 per cent. The precise nature of this interaction is not clear but the decrease is more or less directly proportioned to the increase obtained by applications of pen-manure alone. See Table XVI.

TABLE XVI.

	Montrose.	Diamond.	Keartons.	Grand Sable.
1933–34 Pen-manure ...	+7·3 %	+28·4 %	+10·8 %	−2·8 %
„ Relative response potash ...	−2·7 „	−5·9 „	+ ·8 „	+5·3 „
1934–35 Pen-manure ...	+13·2 „	+35·6 „	+26·5 „	+33·9 „
„ Relative response potash ...	−6·3 „	−12·5 „	−3·4 „	−8·7 „

In both years pen manure produced its largest increase in yield at Diamond. In 1933-34 the increase of 28·4 per cent. was reduced by 5·9 per cent. by potash, and in the following year the increase of 35·6 per cent. was reduced by 12·5 per cent. At Grand Sable, pen-manure had no effect during the first year and the addition of potash resulted in a slight increase of 5·3 per cent. In the second year, however, pen-manure produced an increase of 33·9 per cent. which was reduced by 8·7 per cent. by potash.

If the action of pen-manure is dependent on its content of nutrients, of which nitrogen appears to be the most important, the relative decrease due to the addition of potash to a dressing of pen-manure is approximately proportional to the nitrogen content of the pen-manure.

The decreases due to potash at Montrose, however, were out of proportion to the increases from pen-manuring. As mentioned above the effect of quality of pen-manure may have been minimised by the high nitrogen content and the low potash/nitrate ratio of the soil. It appears, therefore, that the nitrate content of the soil may also play some part in determining the response to a pen-manure plus sulphate of potash dressing.

Pen-manure plus superphosphate. The small increase in yield of plots receiving this treatment over a treatment of pen-manure alone was not significant and it appears that phosphate plays an unimportant part in determining the yield of arrowroot under St. Vincent conditions.

Pen-manure plus sulphate of ammonia. This treatment produced the largest yields in both years, the increases over the controls being 36·8 per cent. and 41·7 per cent. in 1933–34 and 1934–35 respectively, whereas the corresponding increases over pen-manure were 24·4 per cent. and 13·2 per cent. See Table XVII.

TABLE XVII.

	Montrose.	Diamond.	Keartons.	Grand Sable.	Average.
Relative increase sulphate of ammonia 1933–34 ...	21·7 %	24·7 %	26·6 %	24·5 %	24·4 %
Relative increase sulphate of ammonia 1934–35 ...	12·1 %	11·6 %	17·7 %	11·6 %	13·2 %

In 1933–34 the relative increases over pen-manure at all centres varied little from the average figure 24·4 per cent. Further, the increase at Grand Sable, where the pen-manure treatment failed, was 24·5 per cent. It seems, therefore, that this year the effect of sulphate of ammonia plus pen-manure was additive and that the response to a dressing of 300 lb. sulphate of ammonia by itself and in combination with pen-manure was about 24 per cent. increase in yield.

In 1934–35, however, the result was no longer the simple addition of the increases due to each treatment. The change in the response of the mixture

relative to pen-manure was not due to a change in the response to sulphate of ammonia as the increase from the complete fertilizer (containing sulphate of ammonia) was 30·6 per cent. in 1933–34 and 32·5 per cent. in 1934–35. Also the response to pen-manure actually increased from an average of 10·6 per cent. in 1933–34 to 25·2 per cent. in 1934–35. There is therefore some interaction resulting from applications of sulphate of ammonia and pen-manure that tends to reduce the response of the combination. Turner (16) working on sugar-cane soils in Trinidad found that in certain circumstances, sulphate of ammonia can completely mask the increment in yield due to pen-manure.

This interaction did not appear in the first year when the response to the pen-manure was low, *i.e.*, when the quantity of available nitrogen due to pen-manure was small. When, however, this latter increased as in 1934–35, the interaction took place possibly because nitrogen was no longer the limiting factor. The interaction seems to be correlated with the potash/nitrate ratio of the soil. Apparently on soils with a potash/nitrate ratio below about 6 the addition of sulphate of ammonia to pen-manure resulted in an increase of only 11–12 per cent. whereas above this the response was greater. On soils with a very high potash/nitrate ratio much larger dressings of pen-manure plus sulphate of ammonia would possibly continue to produce additive effects.

Complete artificial fertilizer (N.P.K.). This treatment resulted in an average increase in yield of 30·6 per cent. in 1933–34 and 32·5 per cent. in 1934–35. The individual figures, however, vary a good deal as shown in Table XVIII.

TABLE XVIII.

	Montrose.	Diamond.	Keartons.	Grand Sable.	Average.
1933–34 ...	22·0 %	52·2 %	27·7 %	25·4 %	30·6 %
1934–35 ...	22·5 %	43·2 %	22·9 %	47·5 %	32·5 %
Average ...	22·25 %	47·7 %	25·3 %	36·45 %	31·5 %

The magnitude of the response, however, was about the same in both years at any one centre with the exception of Grand Sable. For this reason the average figures for the two years are given. The variation in these average figures can be again best explained by considering the potash/nitrate ratios. The fertilizers used had a relatively high proportion of potash (90 lb. K_2O per acre) as potash plays an important role in the storage of starch. A manure fairly rich in nitrogen and moderately so in potash was therefore added to soils of varying potash/nitrate ratios. At Montrose where the potash/nitrate ratio was very low the response was limited to 22 per cent. The small increase in yield may have been due to the high nitrogen content of the soil, and possibly to a depression of the yield due to the potash in the fertilizer. At Keartons, on the other hand, where the potash/nitrate ratio was very high the increase in yield was again low. It appears that the depressing action of the high potash content of soil plus fertilizer again limited the response. At the other two centres where the potash/nitrate ratio was moderate much larger increases were obtained.

Conclusions and Summary. The treatments resulting in outstanding increases in yield in the recent experiments described above were mulching, pen-manure, pen-manure plus sulphate of ammonia, and a complete artificial fertilizer. The increases were all significant and could be due to chance less than once in a hundred times.

Other treatments included in this series were pen-manure plus superphosphate which produce yields not significantly different from those obtained

from pen-manure alone, and pen-manure plus sulphate of potash which produced yields significantly less than those from pen-manure alone. It is concluded, therefore, that phosphate is not important in determining the yield of arrowroot in St. Vincent when combined with pen-manure which already contains a fair percentage of phosphate. Potash, on the other hand, was harmful when added to pen-manure.

All the treatments resulting in large increases in yield involved the addition of nitrogen to the soil and, apparently, those containing the highest percentage of available nitrogen produced the largest increases. Mulching, however, produces remarkable increases which cannot be accounted for simply by the nitrogen content as compared with the other manures. It is suggested that the action of a mulch may be due to the slower rate at which the nitrogen becomes available, resulting in a more efficient utilisation of this nutrient by the plant.

Applications of sulphate of ammonia plus pen-manure produced significantly greater yields than pen-manure alone, proving that the nitrogen available in a dressing of 10 tons of pen-manure per acre was not sufficient to meet the requirements of arrowroot under St. Vincent conditions. Evidence is adduced to show that dressings of 10 tons of pen-manure per acre and 300 lb. of sulphate of ammonia per acre both resulted in increases in yield of approximately 25 per cent. The 60 lb. of nitrogen in the 300 lb. of sulphate of ammonia, therefore, are insufficient to meet the requirements and the quantity of sulphate of ammonia to be added for maximum profit would probably be greater. On account of the high solubility of sulphate of ammonia and the sandy nature of St Vincent soils, a larger quantity of sulphate of ammonia would probably be more effective if applied in two or more doses.

The economic results of manuring considered in the appendix show that the profits per acre from the various treatments are mulching $16.38, pen-manure $8.20, pen-manure plus sulphate of ammonia $18.00, and complete fertilizer $15.35. The returns from pen-manure and pen-manure plus sulphate of ammonia are based on the yields obtained in the second year, for the reasons stated above. The probable profits to be derived from a dressing of 300 lb. of sulphate of ammonia alone are $17.53.

In addition to the primary effects already mentioned there are certain others, not yet established as being statistically significant, which are indicative of an interaction between the potash and nitrogen contents of the manures and the potash/nitrate ratio of the soil. Pen-manure in 1934–35 and a complete fertilizer in both years produced their maximum effects on soils of moderate potash/nitrate ratios. On soils of high and low ratios manures were less effective, especially on the soil with the low ratio. On all soils the response to the complete fertilizer was greater.

When a manure rich in potash (pen-manure plus sulphate of potash) was added, a significant decrease, as compared with pen-manure alone was obtained, which on each soil appeared to be more or less proportional to the increase obtained from pen-manure alone. That is, the decrease was least on the soil with the highest potash/nitrate ratio, presumably because the effect of the pen-manure alone had already been counteracted to the largest extent by the potash content of the soil. On the soil with low ratio where the general yield level was high and the response to pen-manure and other fertilizers relatively low, the decrease was less than would have been expected. Actually, however, it was the greatest relative to the increase.

When a dressing rich in nitrogen (pen-manure plus sulphate of ammonia) was added, there was a significant increase in yield over pen-manure alone and the relative increase was greatest on the soil with the highest potash/nitrate ratio. On the other soils, the relative increase was approximately the same. These effects are most satisfactorily explained if the potash and nitrogen contents of the manures are taken into consideration. Pen-manure as a rule contains a high

percentage of potash relative to nitrogen, whereas in the complete artificials used, the relative proportion was moderate. In all cases potash whether present in the soil or manure tended to depress the increase obtained from nitrogen alone but the depressing action was greatest when the potash/nitrate ratio was highest, *i.e.*, of both soil and manure combined. The smallest increases from all treatments were obtained at Montrose where the ratio was low but here it appears that the high initial nitrogen content tended to restrict the increase from the farther addition of nitrogen.

It appears, therefore, that on the average St. Vincent soil the potash/nitrate ratio is unsatisfactory for the production of maximum yield and that, pending further investigations, it would be unwise to add potash in combination with nitrogen to these soils. It must be emphasised, however, that the above are merely indications and that the experiments were not designed to elucidate the nature of the interaction between nitrogen and potash. These indications, however, are strongly suggestive of such an interaction and will be used as a basis for further investigations. Experiments will be laid out in 1935–36 in which treatments of varying doses of nitrogen, potash and phosphate will be combined in all possible ways. It is hoped that these experiments will indicate the maximum economic application of sulphate of ammonia and the nature of the interaction between the three nutrients.

Attention must be drawn to the fact that all the above yields are expressed in pounds of rhizomes, whereas the arrowroot grower is, in the final analysis, interested only in the yield of starch. It is possible that a treatment producing a maximum increment in yield of rhizomes may not have a similar effect on the yield of starch. It is expected, however, that a small experimental starch mill will be erected at the Experiment Station by the St. Vincent Co-operative Arrowroot Association during the coming year.

In conclusion the sincere thanks of the writer are due to the Chairman and members of the Board of Management of the Association, and to all those planters who so kindly, and often at great inconvenience co-operated in the conducting of these experiments and were largely responsible for their success. Also the writer is deeply grateful to Mr. A. K. Briant, Superintendent of Agriculture, whose encouragement and great help in the discussion and presentation of the above data has been invaluable.

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APPENDIX.

Economic aspects of manuring.

The ultimate object of any system of manuring is to achieve an increase in the ratio of yield to total cost of production. The profits derived from any treatment may be determined by subtracting from the value per acre of the increment in yield all the costs incidental to the production of this increment. In the case of Arrowroot the additional expenses are :—1. Cost of manures. 2. Cost of transport of manures. 3. Cost of application of manures. 4. Cost of digging increased yield. 5. Cost of transport of increased yield. 6. Cost of manufacture and bagging of starch from increased yield. 7. Cost of transport of extra starch.

1. Cost of manures. In 1934 the c.i.f. St. Vincent price of sulphate of ammonia was £7. 19. 6 per ton, sulphate of potash £12. 17. 0 per ton and superphosphate £4. 19. 0 per ton.

The cost of the artificials per acre were therefore :

300 lb.	sulphate of ammonia ...	$ 4.98
180 lb.	sulphate of potash ...	4.96
270 lb.	superphosphate ...	2.86
	Complete fertilizer ...	12.80

No definite figures are available for the cost of production of pen-manure in St. Vincent but it may be conservatively estimated to be $1.20 per ton, *i.e.*, $12.00 per acre.

The cost of production of a mulch has been calculated to be $5.20 per acre of land treated :—seed $2.00, rental of land $2.80 and cutting of mulch $0.40.

2. Transport of manures. An average cartload is about 14 cwt. and a cart on the average may take six loads per day from the estate building to the field. The average cost of labour and the feeding of the oxen would be about $1.00. Cost of transport per acre would be therefore :—

Pen-manure	...	$ 2.40
Sulpate of ammonia	...	0.05
Complete artificial	...	0.13

3. Cost of application. Two women at $0.12 each can broadcast artificials over one acre per day. Hence cost of application of artificials would be $0.24 per acre.

Pen-manure, if dumped in the field may be spread at a cost of $0.30 per acre. If, however, it has to be headed from heaps to the field, the cost of application rises rapidly and may even become prohibitive.

4. Cost of digging increased yield. The average price paid for digging arrowroot is $0.06 per basket of approximately 100 lb.

5. Cost of transport of arrowroot. Cost of transport of one basket is approximately $1\frac{1}{4}$ cents.

6. Cost of manufacture. In a well organised factory producing on the average 15 barrels of starch per day, the cost of labour is $6.00 or $0.40 per barrel. To this must be added overhead charges and depreciation which would probably amount to a further $0.10 per barrel.

7. Cost of transport to Association buildings. $0.20 per barrel.

The average yield per acre is 15,000 lb. of rhizomes (150 baskets) and, on the average, about 16 per cent. starch is extracted, so that the average starch yield per acre is 12 barrels per acre. During the past year the Association netted $4.91 per 100 lb. of grade 2 starch and $4.36 per 100 lb. of grade 3. The average net value of a barrel of starch (200 lb.) would be therefore $9.20. The profits per acre to be derived from the application of the various manures, calculated on the above figures are given in Table XIX.

TABLE XIX.

	Pen-manure.	Pen-manure plus sulphate of ammonia.	Complete fertilizer.	Sulphate of ammonia.	Mulching.
Av. increase in yield.	25o/o	42o/o	31·5o/o	25o/o	26o/o
1. Manures ...	$12.00	$16.98	$12.80	$ 4 98	$ 5.20
2. Transport (manures) ...	2.40	2.45	0.13	0.05	1.00
3. Application ...	0.30	0.54	0.24	0.24	0.40
4. Digging ...	2.25	3.78	2.84	2.25	2.25
5. Transport (rhizomes) ...	0.45	0.75	0.55	0.45	0.45
6. Manufacture ...	1.50	2.50	1.88	1.50	1.50
7. Transport (starch) ...	0.60	1.00	0.75	0.60	0.60
Total cost per acre ...	$19.40	$28.00	$19.15	$10.07	$11.40
Value of increase per acre ...	27.60	46.00	34.50	27.60	27.78
Profit per acre ...	$ 8.20	$18.00	$15 35	$17.53	$16.38

Cassava Industry.

The area planted under cassava each year is largely dependent on the price of cassava starch compared with the prices of other crops, especially cotton and arrowroot. According to Customs returns, (see Table IV) it appears that the low prices obtained for the large quantity of cassava starch exported during 1933 were largely responsible for a reduction in the 1934 exports. Of the 480,587 lb. exported in 1934, 337,628 lb. were shipped to Trinidad, 85,139 lb. to Barbados and 55,219 lb. to Martinique.

The local prices for cassava starch are much higher than those obtainable in Canada and the United States. The consumption in Canada, however, is very large and constant, and the industry could be considerably expanded if growers in

St. Vincent could compete with growers in the Far East. If costs of production could be reduced, the St. Vincent growers would have a considerable advantage as their transport charges would be very much lower. There is no doubt that costs of production could be decreased in St. Vincent by improving the cultivation and manuring of the crop, and by introducing more modern factory methods.

Syrup and Sugar Industry.

The rugged nature of St. Vincent renders it almost impossible to grow sugar cane on large continuous tracts of land and in most districts the erection of large up-to-date sugar factories would not be economic. One small sugar factory has however been erected in the most suitable situation in the island, and at present is the only factory manufacturing sugar and rum. During 1934 the output of the factory was 1,520 tons of sugar and 26,919 proof gallons of rum of which 750 tons and 8,060 gallons respectively were exported.

The other cane growing areas are relatively small and isolated, and usually confined to a single valley, and the estates concerned are dependent on the syrup industry. Most of the syrup factories operating have been in existence for a great many years and on account of difficulties which have been experienced in the past, scientific methods of controlling the quality of the syrup manufactured are being introduced.

The quantity of syrup exported from the island during 1934 was 269,233 gallons valued at £11,218.

Table XX gives the quantities and values of sugar and syrup exported during the last 10 years. In the last column the total exports of sugar and syrup are given, it being estimated that 300 gallons of syrup are equal to a ton of sugar.

TABLE XX.

Year.	Sugar lb.	Value £	Syrup Gallons.	Value £	Total Value.	Exports calculated as tons sugar.
1925			268,118	19,672	19,672	1,220
1926			337,099	16,523	16,523	1,123
1927	839,000	6,947	171,063	10,496	17,443	945
1928	2,081,408	14,193	167,044	9,471	23,671	1,486
1929	2,408,000	14,095	287,941	12,562	26,671	2,035
1930	1,834,560	9,209	183,786	7,360	16,569	1,431
1931	1,222,000	5,100	222,057	8,380	13,480	1,240
1932	448,000	1,900	164,040	5,994	7,894	1,080
1933	1,904,000	8,162	278,528	11,624	19,786	1,778
1934	1,680,000	5,979	269,233	11,218	17,197	1,647

Coco-nut Industry.

The coco-nut industry was severely affected during the year by the low prices of copra. The London prices decreased from £9. 13. 2 per ton in January, 1934 to £9. 4. 3 in May, but improved towards the end of the year when £10. 0. 0 was being offered. The shipping of whole nuts, however, proved to be more remunerative, and as the nuts produced in St. Vincent are of excellent quality, considerable quantities were exported during the last six months of the year.

The exports for the year consisted of 2,015,675 lb. copra valued at £6,551 and 979,988 nuts valued at £2,538. Comparative figures for the last ten years are given in Table XXI.

TABLE XXI.

Year.	Coconuts.		Copra.		Total Value £.
	Number.	Value £.	Pounds.	Value £.	
1925	9,435	20	661,339	5,512	5,532
1926	20,463	102	762,563	9,826	9,928
1927	11,383	52	1,198,441	10,083	10,135
1928	26,703	113	1,505,093	12,543	12,656
1929	118,500	502	1,879,558	11,396	11,898
1930	66,418	273	1,810,167	11,312	11,585
1931	88,185	366	1,842,477	7,755	8,121
1932	72,130	281	2,227,631	11,426	11,707
1933	17,713	38	2,149,641	8,978	9,016
1934	979,988	2,538	2,015,675	6,551	9,089

Cotton Industry.

Sea Island. The area planted in Sea Island cotton during the 1933-34 season was 1,216 acres. Owing to the exceptionally wet weather experienced during the latter part of 1933 the yield obtained was very low, consisting of 99,750 lb. of lint or an average of 82 lb. per acre.

The Close Season for cotton was from June 1st to August 31st.

The stocks of Sea Island cotton unsold decreased considerably during the year, from 398,600 lb. in November, 1933 to 148,560 lb. in November, 1934. At the end of December, 1934, almost all the stocks had been sold. The improved demand resulted in the area planted during 1934 being increased to 1,464 acres. The areas planted by planters and peasants are given in Table XXII.

TABLE XXII.

1934–35.

			Acres.	Acres.
844	Peasants,	St. Vincent ...	570	
78	,,	Bequia ...	34½	
8	,,	Battawia ...	13	
930				617½
14	Large Growers,	St. Vincent ...	800½	
2	,, ,,	Grenadines ...	46	
16	,, ,,			846½
				1,464

The areas planted by peasants and large growers in the 1933-34 season were 678 acres and 538 acres respectively.

The period September 1st to December 31st 1934 was very favourable both for the germination of the seeds and the subsequent growth of the plants. There was a small amount of wilting of young seedlings and aphis attacks were quite common.

Cotton statistics for the past ten years are given in Table XXIII and XXIV. The value of the cotton exported during 1934 was £9,346.

TABLE XXIII.

Crops.	Area planted Acres.	Weight of lint, lb.	Weight of lint, per acre lb.
1925–26	4,893	585,483	120
1926–27	6,156	507,240	82
1927–28	3,364	328,188	97
1928–29	3,386	263,808	79
1929–30	1,758	262,382	150
1930–31	3,955	605,280	153
1931–32	1,802	209,505	116
1932–33	669	85,852	122
1933–34	1,216	99,750	82
1934–35	1,464	...	...

TABLE XXIV.

Year.		Export of lint, lb.
1925	..	473,219
1926	..	588,793
1927	..	446,274
1928	..	349,246
1929	..	282,903
1930	..	256,167
1931	..	456,089
1932	..	148,860
1933	..	160,792
1934	..	204,519

Manurial Experiment on Cotton.

During the season 1934-35 the Department laid down a cotton manurial experiment at Diamond Estate. The site chosen was about an acre of a fairly flat portion of a field, sloping very slightly to the east. The soil at the eastern end of the field was fairly heavy but it gradually changed to a lighter texture towards the west.

The lay out of the experiment was a 6 x 6 latin square, each plot being 10 x 12 yards or approximately $\frac{1}{40}$ acre. The whole field was ridged with banks 4 feet apart running from east to west. Each plot consisted of nine banks 10 yards long, in each of which were made twenty planting holes 18 inches apart. Every tenth bank and every twenty-first planting hole along the banks were used as guard rows to separate the plots.

No cultivation was done previous to making the banks. The weeds (chiefly "nut-grass" and Bahama grass) were simply chopped off with hoes, ranged, and buried beneath the banks during their formation.

The field was planted on September 12th, and supplied on September 19th and October 9th. Every effort was made to obtain two growing plants in each of the 180 holes in each plot, but owing to a shortage of seed this was found to be impossible.

The manures were applied on October 8th and 9th in small drills around the plants and immediately buried. The different treatments given were as follows:—

(*a*)	Control. No manure			
(*b*)	Cotton seed meal	1,800	lb.	per acre.
(*c*)	Sulphate of ammonia	3	cwt.	,, ,,
(*d*)	,, ,, potash	2	,,	,, ,,
(*e*)	Superphosphate	4	,,	,, ,,
(*f*)	Sulphate of ammonia	3	,,	,, ,,
	,, ,, potash	2	,,	,, ,,
	Superphosphate	4	,,	,, ,,

The plants to which sulphate of ammonia had been applied could be distinguished within a fortnight after the application of the manures, by their darker green colour and more vigorous growth. A week later similar but less pronounced effects were also shown by the plants which had received a dressing of cotton seed meal. The short time taken for this manure to become available to the plants was rather surprising.

The after-cultivation differed in no respect from ordinary estate practices, and consisted of weeding and remoulding the banks when necessary. The eastern side of the field suffered on several occasions during heavy rains from poor drainage. As the time of picking approached the differences between plots receiving different treatments became more marked. The height and vigour of the plants in the plots appeared to vary more or less in proportion to the yields which were finally obtained.

Picking commenced on January 10th and finished during the last week in March. Each picking from each plot was weighed separately, and the pickings from each plot were then bulked and weighed when they were thoroughly dry at the end of the season.

The plan of the experiment and yields of seed cotton obtained in half pounds per plot are shown in Table XXV.

TABLE XXV.

(B) 97	(F)123	(C)118	(A) 69	(D) 63	(E) 57
(A) 66	(D) 71	(F)112	(E) 65	(B) 85	(C)103
(C) 84	(E) 67	(B) 94	(D) 69	(A) 67	(F) 95
(F)112	(C) 96	(A) 59	(B) 95	(E) 58	(D) 68
(D) 64	(B) 90	(E) 84	(C)105	(F)102	(A) 60
(E) 72	(A) 56	(D) 73	(F)106	(C) 94	(B) 80

The analysis of variance is given in Table XXVI.

TABLE XXVI.

Due to		D. F.	S. S.	Variance.	½ log e Variance.
Total	—	35	13,241		
Rows	—	5	294		
Columns	—	5	662		
Treatments	—	5	11,185	2,237	2·4108
Error	—	20	1,100	55	0·8015
					Z=1·5093

From Fisher's Tables, when P = ·01, $n_1 = 5$ and $N_2 = 20$, Z = ·7058. As the experimental value of Z is greater than the calculated value, the treatments have produced significant effects on yield.

The treatment means in half-pounds per plot are as follows:—

(A) 63 (B) 90 (C) 100 (D) 68 (E) 67 (F) 108

It has been calculated that any difference between two means which is greater than 8·9 half-pounds is significant. It is evident therefore, that

(1) There is no significant difference between the yields obtained from treatments A, D and E.
(2) The yields obtained from treatments B, C and F are significantly better than those obtained from A, D and E.
(3) Treatments C and F are significantly better than B.
(4) Treatment F is just not significantly better than treatment C.

The experiment was carried a stage further by separating out the stained cotton, ginning the white lint, and obtaining for each plot (1) the weight of white seed cotton, (2) the weight of white lint, (3) the weight of prime seed, (4) the ginning percentage and (5) the weight of stained lint. The results are summarised in Table XXVII.

TABLE XXVII.

Treatment.	Total Seed Cotton.	White Seed Cotton.	White Lint.	Prime Seed.	Ginning %	Stained Lint
	lb. oz.	lb. oz.	lb. oz.	lb. oz.		lb. oz.
(A) Control	188 8	169 8	42 12	125 9	25·2	3 13
(B) C. S. M.	270 8	252 8	64 2	186 4	25·35	3 2
(C) N	300 0	276 0	70 9	201 13	25·4	4 15
(D) K	204 0	185 0	46 6	137 5	24·9	4 4
(E) P	201 8	186 4	46 11	138 3	25·1	3 4
(F) N. P. K	325 0	301 0	77 3	221 11	25·45	5 4
Totals	1,489 8	1,370 4	347 11	1,010 13	25·3	24 10

The small variation in the ginning percentages obtained from the different treatments is rather remarkable and unexpected. As the highest percentage obtained from any individual plot was 26·3 and the lowest 24·4, it seems probable that the errors in obtaining the values were small, and that the figures given are very near to the true values.

As the object of growing cotton is primarily to obtain white lint, the yields of the different plots expressed in ounces of lint were also subjected to statistical analysis.

The plan of the experiment and the yields of the plots in ounces of white lint are shown in Table XXVIII.

TABLE XXVIII.

(B) 181	(F) 228	(C) 220	(A) 122	(D) 107	(E) 106
(A) 120	(D) 125	(F) 213	(E) 120	(B) 161	(C) 192
(C) 161	(E) 123	(B) 179	(D) 132	(A) 126	(F) 182
(F) 202	(C) 179	(A) 105	(B) 180	(E) 108	(D) 128
(D) 115	(B) 171	(E) 155	(C) 200	(F) 202	(A) 111
(E) 135	(A) 100	(D) 135	(F) 208	(C) 177	(B) 154

By means of the Z test it was found that differences due to treatment were significant. It was also calculated that a difference between any two means greater than 17·1 ounces was significant.

The treatment means in ounces were as follows :—

(A) 114 (B) 171 (C) 188·2 (D) 123·6 (E) 124·5 (F) 206

The conclusions to be drawn from the experiment are therefore :—

(1) Treatments B, C and F are significantly better than treatments A, D and E.

(2) Treatment F is significantly better than treatments B and C.

(3) Treatment C is significantly better than treatment B.

These results differ from those obtained in analysing the yields expressed as seed cotton in only one respect, namely, that the mean yield of treatment F is here significantly greater than the mean yield of C.

Previous experiments on the manuring of cotton in St. Vincent conducted during the years 1912-17 have been described by Harland in the West Indian Bulletin Vol. XVI p. 169. These experiments did not permit any conclusions to be drawn as to the relative merits of the various treatments given. The extreme variations obtained between plots receiving the same treatment, and between the yields obtained from the same plot in two consecutive years are very remarkable. Planting at that time was carried out in June and the crop was picked during the wettest months of the year, when conditions were much more inducive to shedding and boll-rotting than they are during the present picking season. It may be possible, therefore, that the application of manures, which would induce more vigorous growth, would further increase the amount of shedding. Also, the greater development of foliage would increase the relative humidity in the environment of the plants and thus make conditions more favourable for the development of boll diseases. If such were the case, the application of some manures, for example nitrogenous manures, might prove to be more detrimental than advantageous.

With the planting season now starting on September 1st it seems reasonable to assume that during the first two or three months the primary aim should be to produce fairly robust plants which are capable of forming a strong scaffolding for the production of bolls, but avoiding undue vegetative development which might induce excessive shedding. The advent of the dry season would then probably check vegetative growth and provide conditions favourable to boll maturation.

In view of the results obtained from the experiment conducted during 1934-35 the above assumption appears to be justified. The application of treatments B, C and F each resulted in the production of larger plants, and although at the end of the wet season these plants shed more bolls, especially from the lower branches, than plants in other plots, the number of bolls which finally matured was much higher.

The results obtained from the 1934-35 experiment do not prove that similar results would have been obtained if the experiment had been conducted in another field or even on the same field in a different season. Nor is it supposed that the quantities of the manures used or the time of application were the optimum, as it is possible, for instance, that a smaller dressing of sulphate of ammonia applied at a later date may have given as good results as those obtained in the experiment. Before definite recommendations can be made as to manurial treatments it is necessary to conduct other experiments in various parts of the island and in a number of different seasons. The experiment indicates, however, that nitrogen was the element most deficient under the existing circumstances. As the manurial experiments carried out on arrowroot by Robinson in St. Vincent during the past two seasons have all shown that nitrogen is the limiting factor in the production of arrowroot rhizomes, it seems very probable that the indications obtained from the cotton experiment would be obtained under other seasonal and soil conditions in St. Vincent.

West Indian Sea Island Cotton Association. A meeting of the Executive Committee of this Association was held in Montserrat in April 1934 at which St. Vincent was represented by Mr. A. G. Hazell. The St. Vincent delegates who attended the Annual General Meeting of the Association in Montserrat in November 1934 were Dr. G. A. MacDonald and the Agricultural Superintendent.

Reports on these meetings have been circulated by the Association.

Marie Galante Cotton. The acreage returns for Marie Galante for the season 1934-35 are as follows :—

TABLE XXIX.

Season 1934-35		Acres.	Acres.
142 Peasants, Union Island	...	434	
39 „ Canouan	...	78	
2 Large Growers, Grenadines	...	140	
Total	...		652

The acreage grown during the 1932-33 and 1933-34 seasons were 801 acres and 719 acres respectively.

Cacao Industry.

The future prospects of the cacao industry in St. Vincent are not very encouraging. The low yields and poor prices which are now obtained are not conducive to good cultivation and, in general, very little interest is taken in the crop. The average quantity of cacao exported during the last three years is only 58 per cent of the average for the three previous years, and it seems likely that the exports will continue to decline.

The quantity of cacao exported during 1934 was 94,758 lb. valued at £894. Export figures for the last ten years are given in Table XXX.

TABLE XXX.

Year.		Weight, lb.
1925	...	154,821
1926	...	174,599
1927	...	135,490
1928	...	179,918
1929	...	156,405
1930	...	180,373
1931	...	146,990
1932	...	84,679
1933	...	100,230
1934	...	94,758

Banana Industry.

Arrangements were made during 1934 to promote the development of a banana industry in St. Vincent. A co-operative Banana Association was created by Ordinance to market and to control the export of all Gros Michel bananas from the island. The Association has since entered into an agreement to supply the Canadian Banana Company with all fruit available for export during the five year period 1936-1940. The Company has agreed to purchase all

bunches larger than seven hands, with option to purchase six hand bunches if desired, at a rate equivalent to 50 cents per count bunch delivered at the water front in Kingstown. Bunches of six, seven, eight and nine or more hands are to be counted as $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ count and count bunches respectively. The Company has also agreed to accept fruit before 1936 if and when more than 250 bunches are available for shipment at any one time.

In July a Banana Instructor was appointed for a period of three months to advise planters and peasants on all matters relating to the growing of bananas for export. His term of office has since been extended for a further nine months.

The planting of bananas has proceeded only very slowly and at the end of 1934 about 230 acres of new cultivation had been established. This has been due to several reasons, namely:—

(1) The high incidence of Panama disease in the Marriaqua Valley has made planters in this and neighbouring districts proceed rather cautiously.
(2) Planting material is very scarce in some of the best areas particularly on the Leeward coast.
(3) Peasants in all districts are rather dubious about planting and will probably continue to be so until they are assured that the larger growers are being successful.
(4) The difficulties of transporting fruit from some of the best potential banana growing areas are at present very great. The possibility of removing some of these difficulties by carrying out improvements to roads is now under consideration.

It is hoped to make regular shipments of 250 or more bunches after August or September 1935.

Panama Disease. In August 1934 this disease was found to be much more prevalent in St. Vincent than was expected. The incidence in the Marriaqua Valley is especially high and, as some parts of the Valley are very suitable for the growing of bananas, efforts were at first made to destroy all the diseased stools with B.D.K. oil. This, however, was soon found to be impracticable, and was abandoned for financial reasons.

The incidence of the disease in other districts of the island is not very high. On the whole of the Leeward coast only nine diseased stools have been discovered and these have been destroyed. Efforts are at present being made to control the disease by destroying all diseased stools known to exist outside the Marriaqua Valley.

Progress in Minor Industries.

Maize. The exports of maize during 1934 (34,350 lb. valued at £109) were higher than they have been for the three previous years. During the year the Government Cotton Ginnery reduced the retail price to $1\frac{1}{4}$ cents per lb. in order to get rid of old stocks.

Groundnuts. There is now only one estate producer of groundnuts, and very little interest is taken in the crop by peasants on account of low prices.

Sweet Potatoes. The exports of sweet potatoes during the year amounted to 9,868 bags (160 lb. each) valued at £3,152. Of this quantity 95 per cent. were shipped to Trinidad and the remainder to British Guiana.

Agricultural Legislation, 1934.

Ordinance No. 1 of 1934 relating to Agricultural Credit Societies.
The previous Ordinance No. 12 of 1934 was repealed.

Ordinance No. 2 of 1934 to provide for the imposition of an additional tax on land in respect of the year 1934.

Ordinance No. 3 of 1934 to impose a levy on Sea Island cotton exported from the Colony for the purpose of furthering the interests of the cotton industry. This levy will provide funds for annual contributions to the West Indian Sea Island Cotton Association.

The Sea Island Cotton Lint (Duty) Ordinance 1933 and the Sea Island Cotton Lint (Duty) (Amendment) Ordinance 1933 were repealed.

Ordinance No. 4 of 1934 to create a body corporate to market bananas and to regulate and control the export thereof.

Ordinance No. 14 of 1934 to make provision for the fixing of a minimum wage for labour.

Orders in Council. Date when gazetted is given :—

(1) 20th March 1934. Under Cotton Protection Ordinance declaring close season for cotton from June 1st to August 31st, 1934.

(2) 30th June 1934. Under the Cotton Export Levy Ordinance 1934 imposing levy of three quarters of a cent per pound on all Sea Island cotton lint exported.

(3) 27th December 1934. Under the Export Duties Ordinance 1933 fixing export duties on Copra (sliding scale).

Rules, Regulations, etc. Date when gazetted is given :—

(1) 18th September 1934. Under Agricultural Credit Societies Ordinance 1934. Regulations for the control and management of the Three Rivers Agricultural Credit Society. Since repealed in 1935.

(2) 2nd October 1934. Under Importation of Animals (Diseases Prevention) Ordinance, 1933. Regulations governing importation of animals.

(3) 2nd October 1934. Under Importation of Plants Diseases Prevention Ordinance. Form of health certificate for plant imports and exports.

(4) 23rd October 1934. Under Banana Association Ordinance 1934. Fixing entrance fee for admission to the Association at four shillings and two pence.

Pupil Teachers' Examination in Agriculture.

The Agricultural Superintendent undertook the examination of the First, Second and Third Year Pupil Teachers in Agriculture in October 1934.

Science Teaching.

This work is undertaken by Mr. D. S. Cozier, Science Master at the Grammar School.

Details of Staff and Administration.

The sum of £2,351 was voted for the upkeep of the Agricultural Department during the year 1934.

The Agricultural Assistant acted as Agricultural Superintendent until July 15th when Mr. A. K. Briant, the present Agricultural Superintendent, was appointed.

A new temporary post of Banana Instructor was created on July 16th by the appointment of Mr. George Fraser.

The appointment of Mr. P. Morrison, Agricultural Assistant, terminated at the end of August after which he obtained four and a half months leave on full pay.

Mr. C. K. Robinson was appointed Agricultural Assistant, on November 1st in conjunction with his duties as Scientific Officer to the Arrowroot Association. This appointment is for a period of three years.

Mr. F. A. DaCosta resigned his appointment as Officer-in-Training at the end of November 1934.

The details of expenditure are given below :—

	£	s.	d.
Salary, travelling allowance, Agricultural Superintendent	300	10	10
Salaries, travelling and house allowances, Agricultural Assistants	456	11	1
Salary and travelling allowance, Banana Instructor ...	102	11	3
Salaries, Foreman, Botanic and Experiment Stations, Cotton Inspector, Officer-in-Training, Clerical Assistant, Laboratory Assistant to Cotton Research Officer, and travelling allowances, Cotton Research Officer and Cotton Inspector	392	11	4
Salary, Government Vaccinating Officer ...	19	9	6
Upkeep, Botanic and Experiment Stations, (labour, manures, tools, seeds, etc.)	534	0	8
Destruction of food plants of the Cotton Stainer ...	21	8	3
Destruction of diseased Banana Plants	11	1	9
Special Cotton Investigations	45	1	6
Special Services	21	8	3
Visit of Dr. Myers to St. Vincent	5	5	0
Contribution to Imperial College of Tropical Agriculture ...	328	0	0
Contribution to various Scientific Institutions, etc. ...	44	0	0
Total	2,281	19	5

Receipts.

The receipts for the sale of plants and produce at the Experiment Station amounted to £36. 15. 0.

Correspondence.

The number of minute papers dealt with amounted to 203 and the number of letters despatched was 545.

Meteorological Observations.

The rainfall at the Botanic Station for 1934 was 92·71 inches. The average for the last 41 years is 102·4 inches.

Rain was recorded on 306 days at the Botanic Station and on 282 days at the Experiment Station.

The following table gives the mean temperature, average degree of humidity and the mean barometric pressure in inches for each month of the year :—

. Meteorological Observations, Experiment Station, for 1934.

TABLE XXXI.

Month.	Mean Temperature F°.	Average degree of humidity Saturation 100.	Mean Barometric pressure in inches.
January ...	79·6	72·0	29·950
February ...	76·9	69·4	30·016
March ...	76·9	70·7	29·987
April ...	79·1	69·1	29·993
May ...	79·5	73·2	29·973
June ...	80·5	74·4	29·973
July ...	80·8	76·1	29·981
August ...	81·7	72·7	29·976
September ...	81·2	73·0	29·939
October ...	81·0	74·2	29·933
November ...	80·7	73·6	29·901
December ...	78·8	73·9	29·983

Atmospheric Pressure.

The reading of the Barometer, corrected for instrumental error, elevation, temperature and latitude, ranged from 30·111 on February 27th to 29·822 on 22nd and 29th November.

The following table gives the rainfall recorded at the various stations in 1934 :—

TABLE XXXII.

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Botanic Gardens...	6·21	3·43	4·15	3·17	7·53	4·08	9·11	9·99	11·37	12·57	10·31	10·79	92·71
Mesopotamia ...	*	2·07	4·16	1·56	8·02	1·40	9·42	10·26	11·94	7·18	10·12	16·95	83·08
Experiment Station ...	5·55	3·04	3·37	2·51	7·52	3·60	9·32	8·47	10·20	12·30	8·12	8·88	82·88
Chateaubelair ...	*	2·27	2·86	1·54	4·92	5·70	11·70	10·44	11·07	7·48	9·04	14·50	81·52
Sans Souci ...	2·91	1·10	4·39	1·82	4·30	13·40	5·26	7·15	5·45	5·62	10·20	6·07	67·67
Bequia ...	4·20	3·37	1·84	5·00	4·40	2·99	5·07	7·86	9·64	8·06	6·30	7·29	66·02
Barrouallie ...	*	1·66	2·48	1·34	3·08	2·07	7·47	9·33	9·12	7·42	4·27	13·55	61·79
Brighton ...	2·41	1·62	1·78	·86	6·07	1·91	7·10	8·57	8·57	7·88	7·71	5·77	60·25
Troumaca ...	2·87	1·63	1·52	·52	3·82	2·87	6·18	4·75	8·07	5·39	5·43	9·55	52·60
Canouan ...	1·40	1·51	·87	1·29	2·35	1·90	3·04	4·14	4·40	5·04	3·45	3·10	32·49
Union Island ...	2·10	1·50	·70	2·50	3·90	·70	2·35	2·10	3·10	5·50	2·14	2·70	29·29
Mayreau ...	1·69	1·80	·85	1·63	1·90	1·31	1·32	2·44	2·46	4·33	1·90	2·10	23·73
Botanic Gardens, average rainfall, 41 years.	6·43	4·20	4·05	4·04	6·56	11·03	11·71	11·79	11·11	11·92	11·56	7·97	

* Records not available.

Official Visitors, 1934.

The following official visitors paid visits to the island during the year :—

Mr. G. A. Jones, Commissioner of Agriculture, from May 4th to May 13th to discuss and advise on various agricultural matters affecting the Colony.

Mr. A. C. Shill, Marketing Officer, Windward and Leeward Islands from April 27th to May 4th to inspect the work of the Government Fruit and Vegetable Bureau.

Dr. J. G. Myers, Biological Control Research Officer, Imperial College of Tropical Agriculture, November 4th to November 11th to investigate various entomological problems.

Dr. S. C. Harland, Geneticist, Cotton Research Station, Trinidad, from December 14th to December 20th to inspect the work of the Cotton Research Station. He was accompanied by his assistant, Mr. Silow, who remained in St. Vincent until December 28th.

Sir Geoffrey Evans, Principal Imperial College of Tropical Agriculture and party of students visited the Department for a few hours on March 15th and on March 23rd.

Other visitors included Dr. Dunlap, Mr. Sanderson and Mr. Alexander of the United Fruit Company, Mr. A. K. Briant, Assistant to the Commissioner of Agriculture, Mr. Paul of the Department of Agriculture, Ceylon and Mr. W. A. Twyman of the Advisory Committee, West Indian Sea Island Cotton Association.

SECTION II.

Report on Agricultural Credit Societies.

A new Ordinance relating to Agricultural Credit Societies was brought into operation in February, 1934. This Ordinance was modelled on the Ordinance in Trinidad and offers the Societies greater security by compelling each member borrowing money to give a charge on his crops.

The four Societies which were in existence at the beginning of the year have shown little or no activity, one of the reasons being that they are handicapped in being unable to obtain loans for distribution.

A new Society was formed during the year at Three Rivers, and another, at Biabou is ready to function if a loan is obtainable.

Clare Valley-Questelles. This Society is functioning entirely on a sum of £82 which is the property of the Society. Nearly all this money is loaned to members on good security. The Society is one which is likely to flourish if it were assisted by a loan.

Redemption. This Society is in a very dormant condition, as the only money available for distribution is £12 owned by the Society.

Georgetown. This is a very large Society consisting of 86 members, which again is unable to obtain a loan. Funds amounting to £36 are being used as follows :—Amount on loan £21, Government Savings Bank £5, and outstanding loans £10. The Society made an application to Government for a loan of £300 during the year, but Government at present is unable to grant the request.

Troumaca. This Society at the beginning of the year was in possession of a loan from the Troumaca Temperance Society amounting to £31. 13. 4 of which £7. 5. 10 was repaid in December. Outstanding loans amount to about £37. 4. 10 and the cash in hand is £1. 7. 3½. Only two loans (£7. 5. 10 and £1. 0. 10.) were repaid to the Society by members during the year.

Three Rivers. The Three Rivers Agricultural Credit Society was formed in May 1934. Membership of the Society is restricted to holders of land under the Land Settlement Scheme, and it is hoped that the Society will greatly assist members to cultivate their land properly and to pay their annual instalments. A loan of £300 was granted to the Society in July for one year at a very low rate of interest, namely 2½ per cent. and the Society is granting loans to members at 6 per cent. interest. The Society has a membership of 48.

The Arrowroot and Syrup Works on Three Rivers estate are being repaired by Government and will shortly be leased to the Society at a pepper-corn rental.

It is hoped that this Society will operate successfully as this would tend to encourage Government to make loans to other Credit Societies in the future if funds are available for this purpose.

Three Rivers Land Settlement Scheme.

The sale of allotments on the Three Rivers Land Settlement commenced in May 1933. There were 132 allotments for distribution, amounting to 631 acres. In April 1934, 338 acres had been taken up, but sales were fairly slow during the next few months. The regulations in force at that time demanded that 20 per cent. of the value of the land should be deposited by the applicants before their applications would be considered. The remainder of the purchase money plus interest was to be paid in ten annual instalments. At the end of August Government reduced the deposit required from 20% to 10% in order to encourage possible applicants to take up land more quickly. This action had an immediate effect and at the end of the year only eighteen allotments, comprising about 102 acres remained to be distributed.

During the year some of the members who had purchased coconut lands found it very difficult to meet their first annual instalments because even after the coconut trees had been removed the roots interfered with the proper development of their crops. In consequence Government has allowed these members to pay for their land in nine equal but slightly increased annual instalments instead of ten, and to postpone the payment of their first instalments until the end of the second year.

Considering the allottees as a whole, they have paid up their instalments fairly satisfactorily.

SECTION III.

Government Fruit and Vegetable Bureau.

The amount of produce shipped by the Bureau during 1934—details of which are given in Table I—was approximately the same as that shipped during the previous year.

TABLE. I.

Produce.	Canada.	Bermuda.	England.	Total	
				Crates.	Quantity.
Avocado pears ...		78 Tom. Crts.		78	1,380
Julie mangoes ...	17 Tom. Crts.	50 „ „	93 Tom. Crts.	160	5,891
Green limes ...	776 „ „	71 {36 Bush „ / 35 Tom „}		847	22,088 lb.
Tomatoes ...	626 „ „			626	13,729 „
Oranges ...		3 Bush „		3	300

The information and the experience gained from previous years' shipments however, were made use of, and shipments were not made at times when it was thought that markets were unfavourable.

The last shipment of fruit was made on November 3rd after which date no shipments were possible as there was no available accommodation in the Canadian ships.

The Bureau shipped produce delivered by about 125 different growers during the year.

Tomatoes. Exports of tomatoes from the island were again small, and amounted to 837 crates. Of these, the Bureau handled 626 crates containing 13,729 lb. of tomatoes owned by 39 peasants.

In view of the poor prices obtained during December, January and February in previous years, all tomatoes were shipped to Canada during the months of March, April and May by the Bureau. The extreme gross prices obtained in Canada varied from $1.10 for "Choice" and $0.90 for "Gems", for the March shipments, to $1.70 for "Choice" and $1.25 for "Gems", for shipments made in May.

As in the previous year, one cent per lb. was advanced to growers for fruit accepted, and a bonus was distributed at the end of the year, after all expenses, including a commission of 10 per cent. to the Bureau, had been paid. The bonus paid was equal to one and one-seventh cents per lb., and the growers therefore obtained a total net payment of two and one-seventh cents per lb.

The following table summarises the position:—

TABLE II.

Amount advanced on Tomatoes.	Other Local Expenses.	10% Commission, Bureau.	Bonus.	Freight and Canadian Expenses.	Total Expenses.	Gross Sales.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
28 12 0½	42 15 3	11 10 8	32 14 11½	48 10 7	164 3 6	164 3 6

Green Limes. The green limes shipped were purchased outright from growers at the rate of one cent per lb. The majority were sent to Canada, and the remainder to Bermuda. The expenditure and receipts, in connection with the crop, are given as under:—

TABLE III.

(LIMES TO CANADA).

Date.	Cost of Limes.	Local Expenses.	Firm's Charges.	Total Expenses.	Gross Sales less Freight.	Profit.	Loss.
1934.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
3rd June	5 8	6 5	9 2½	1 1 3½	2 3 9	1 2 5½	
17th „	4 3 6	4 8 7	13 8½	9 5 9½	22 4 9½	12 19 0	
1st July	7 10 2½	7 13 10½	2 9½	15 6 10½	24 0 10½	8 14 0	
15th „	14 16 1½	14 19 1	5 4	30 0 6½	55 13 5	25 12 10½	
29th „	13 8 4	13 4 8	4 8½	26 17 8½	17 9 10½		44 7 7
Total ...	40 3 10	40 12 7½	1 15 9	82 12 2½	86 12 11½	48 8 4	44 7 7

TABLE III (*a*).

(LIMES TO BERMUDA).

Date.	Cost of Limes	Local Expenses.	Firm's Charges.	Freight.	Total Expenses.	Gross Sales.	Profit.	Loss.
1934.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1st July	7 11	13 0	10 0	11 2½	2 2 1½	3 10 0	1 7 10½	
29th „	8 0½	12 10½	9 9	11 0½	2 1 8½	3 13 0	1 11 3½	
12th Aug.	10 2	1 1 6½	12 11	16 9	3 1 4½	4 8 0	1 6 7½	
26th „	1 12 7½	1 8 11	13 9	1 9 2½	5 4 6	4 15 0		9 6
7th Oct.	11 10½	10 8	4 2	11 3	1 17 11½	2 0 0	2 0½	
21st „	17 9½	16 2	5 11	16 9	2 16 7½	1 11 0		1 5 7½
3rd Nov.	10 4	8 11	4 4	8 4½	1 11 11½	1 14 0	2 0½	
Total ...	4 18 9	5 12 1	3 0 10	5 4 7	18 16 3	21 11 0	4 9 10½	1 15 1½

Shipments to Canada were made during the months of June and July, and as it was known from shipments made in past years that August shipments would be likely to show a loss, none were made during this month. Unfortunately however, the market declined rather sooner than was expected, and the last shipment made on 29th July produced a loss of £44. 7. 7 which reduced the previous profits realised from £48. 8. 4 to £4. 0. 9.

Shipping limes to Bermuda involved less risk, for although any profits realised were small, very much less was spent on freight than when shipping to Canada, and consequently any losses incurred were also relatively small. The total shipments to Bermuda made a profit of £2. 14. 9.

Avocado Pears. Avocado pears were purchased outright from growers at one cent, or one-third pence each according to quality, and all were shipped to Bermuda. The expenditure and receipts for the crop are given in Table IV, which shows that a final loss of £1. 10. 9 was sustained.

TABLE IV.

Cost of Pears.	Local Expenses.	Freight.	Firm's Charges.	Total Expenses.	Gross Sales	Profit.	Loss.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
7	1 2	1 1½	10½	3 9	7 0	3 3	
1 0 7	1 13 1	1 13 1	1 5 9	5 12 6	5 11 0		1 6
15 1½	1 3 8½	1 4 11	15 4	3 19 1	4 0 0	11	
9 5	15 2½	15 10½	9 2	2 9 8	1 5 6		1 4 2
6 7	11 10½	18 6	9 6½	2 6 6	1 18 0		8 6
2 12 3½	4 5 0½	4 13 6	3 0 8	14 11 6	13 1 6	4 2	1 14 2

Mangoes (*Julie*). The price paid to growers for mangoes was one cent each. Shipments were made to Canada, Bermuda and to England, and the expenditure and receipts in connection with the individual shipments are summarised in tables V, V (*a*) and V (*b*). Losses were made on both shipments to Canada and on one of the three to Bermuda.

On two occasions the Bureau co-operated with the Government Marketing Depôt in St. Lucia by sending joint shipments of mangoes to London so as to obtain information as to the possibility of using the English market. Each St. Vincent shipment was consigned partly to one broker (A) and partly to

another (B). It is interesting to note that on both occasions the sales effected by broker A allowed moderately large profits to be made, while the returns from broker B were far from satisfactory.

Broker A reported that the first consignment appeared to have been carried at too low a temperature and that probably many fruit would not ripen properly. Two crates were sold for 22/8 each and two for 22/6 each. Others were sold for 1/- each. The packing was reported to be unsatisfactory. The second shipment to broker A was reported to be "of good quality and in sound condition", and was sold for 12/- to 15/- per crate. Three crates were used for repacking.

Broker B reported that in both consignments "the fruit arrived in a very green hard condition but unfortunately the bulk of it went rotten before ripening. The packing and grading were good, and, if you could get the fruit here sound, but more mature, we think it would sell reasonably well".

These reports are somewhat contradictory but it seems quite probable that the quality of the fruit was affected to some extent by the conditions of time and temperature under which the fruit was carried.

The nett profits on the English shipments amounted to £3. 13. 10.

During the next few years large numbers of Julie mango trees will be coming into bearing both in St. Vincent, and in other neighbouring British West Indian islands and it is expected that considerable quantities of fruit will be available for export if a suitable market could be developed. This matter is already receiving the attention of the Eastern Section of the Fruit and Vegetable Council and will be discussed at a meeting to be held in April 1935.

TABLE V.

(MANGOES TO CANADA).

Cost of Mangoes.	Local Expenses.	Freight.	Firm's Charges.	Total Expenses.	Gross Sales.	Profit.	Loss.
£ s. d	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d
10 1½	6 9½	5 9	1½	1 2 9½	12 6		10 3½
13 1	9 4½	1 11 3	13 10½	3 7 7	1 11 3		1 16 4
1 3 2½	16 2	1 17 0	14 0	4 10 4½	2 3 9		2 6 7½

TABLE V (*a*).

(MANGOES TO BERMUDA).

Cost of Mangoes.	Local Expenses.	Freight.	Firm's Charges.	Total Expenses.	Gross Sales.	Profit.	Loss.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1 6 0	16 4	19 8½	18 1	4 1 1½	6 14 0	2 12 10½	
1 6 2	19 4	1 2 0½	19 6	4 7 0½	4 13 0	5 11½	
14 5	13 8	13 7½	10 3½	2 12 0	2 11 0		1 0
3 6 7	2 9 4	2 15 4½	2 7 10½	11 0 2	13 18 0	2 18 10	1 0

TABLE V (*b*).

(MANGOES TO ENGLAND).

Cost of Mangoes.	Local Expenses.	Freight.	Firm's Charges.	Total Expenses.	Gross Sales.	Profit.	Loss.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1 19 7	1 9 7	2 0 2	1 2 9	6 12 1	1 17 0		4 15 1
1 15 5	1 6 6½	1 16 0	1 4	4 19 3½	11 8 11	6 9 7½	
1 4 11	1 11 0	1 5 0	1 4 0	5 4 11	10 7 6	5 2 7	
1 7 8½	1 15 0	1 7 9	15 4	5 5 9½	2 2 6		3 3 3½
6 7 7½	6 2 1½	6 8 11	3 3 5	22 2 1	25 15 11	11 12 2½	7 18 4½

Miscellaneous. Apart from the above the only other produce shipped from the Bureau was three crates of oranges which were sent to Bermuda. The oranges were purchased outright at the rate of three for one cent, and the nett profit obtained was 6/6½.

General. In estimating the local expenses in Tables III to V (*b*) the cost of crates has been included as being 13c. per crate, which is a fraction of a cent in excess of the actual cost. The nett profits are therefore very slightly in excess of the figures given.

Statements of Expenditure and Receipts, and Assets and Liabilities for the year are given in Tables VI and VII. These show that a profit of £29. 5. 11 was made on the year's working.

TABLE VI.

STATEMENT OF EXPENDITURE AND RECEIPTS.

1934.		£ s. d.	£ s. d.
1st Jan.	To Balance due Treasury ...	80 1 7	
	Purchase of Produce ...	109 12 5	
	Labour ...	14 2 6	
	Freight and Lighterage ...	26 16 9	
	Porterage ...	6 0 9	
	Bus hire ...	4 2 3	
	Lodge rent ...	12 0	
	Refrigeration ...	4 1 10	
	Making of crates ...	3 15 3	
	Purchase of crates ...	73 13 3	
	Inspection Fee ...	1 4 9	
	Nails and Wood-wool ...	1 4 10	
	Amount due Producers ...	23 11 11	
	Paper and paste ...	7 12 0	
31st Dec.	By Receipts from abroad ...		281 3 9
	,, locally ...		13 11 3
	Sale of Labels ...		2 0 0
	Amount due Treasury ...		59 17 1
		£ 356 12 1	356 12 1

TABLE VII.

STATEMENT OF ASSETS AND LIABILITIES.

1934. *Liabilities.*		£	s.	d.	*Assets.*		£	s.	d.
Balance due Treasury at 31. 12. 34	...	59	17	1	Value of Stock at 31. 12. 34	...	91	8	7½
Unclaimed Bonus 1934	...	14	1	10½	Amount due locally	...		10	11½
„ „ 1933	...		15	5	„ „ abroad	...	12	0	8
		74	14	4½					
Excess of Assets	...	29	5	10½					
		£104	0	3			£104	0	3

REPORT OF COTTON RESEARCH OFFICER FOR THE SEASON 1934-35.

The following information deals with that part of the work of the Cotton Experiment Station of most interest to St. Vincent. The Station's work is technically directed by Dr. Harland.

A. Work on maintaining the purity of the Island's Seed Supply.

Following the customary policy for maintaining the purity of the Island's Cotton Seed supply an area of 0·6 acres was sown at the Station to self-fertilized seed of high bolling V. 135 selections pure for lint length and quality. The flowers were self-fertilized and the 'selfed' seed cotton was collected, dried, stored and ginned separately. The total yield of dried seed cotton from the Station's Multiplication plot (0·6 acres) was 1,161 lb. and from the 'selfed' seed cotton 452 lb. of seed were obtained. At a sowing rate of 8 lb. per acre this quantity of seed is sufficient to plant about 60 acres in September, 1935, and the seed produced from this area will form the Island's seed supply in September, 1936. When it is borne in mind that to facilitate plant examination a single plant is left per hole and that a fair loss of bolls is occasioned by the actual self-fertilization of the flowers and the unavoidable mechanical damage attending the process of self-fertilization, the above figures demonstrate that the Strain V. 135 is capable of producing remarkably good yields.

Six selections were made from the Station's Multiplication area ranging in number of bolls per plant from 178 to 240, and the 'selfed' seed from these will be sown in the Station's Multiplication area in September, 1935.

In order to maintain the length and quality of V. 135, two of the longest linted selections from last season's progeny rows were again grown in pedigree culture, and the two best plants from the best progeny row have been selected for future work.

B. Progress with Red Sea Island Strains.

It will be remembered from former reports that the Red Sea Island Strains are self-fertilized selections from a third backcross of Trinidad Red Kidney x Sea Island and that as they have red plant bodies and weak corolla spots any rogues can easily be detected.

Twenty-seven selections of the fourth generation of the third backcross were grown in pedigree culture this season. In brief, these selections when compared with standard V. 135 can be said to be more robust, more resistant to Angular Leaf Spot and Aphis, less prone to damage from high winds owing to their stronger root systems and slightly superior in lint length, lint index, lint weight per boll and ginning percentage. They, however, mature about one week later, have less seeds per boll and do not produce as many bolls per tree.

A yield test carried out this season between V. 135 and Red Sea Island gave significant results, for weight of seed cotton, in favour of the former. On analysing the factors responsible for yield it was apparent that V. 135 owed its superiority to its having a greater number of bolls per tree. Worked out on the basis of lint per acre, however, the yields were V. 135=626·4 lb. and Red Sea Island=616·9 lb. the difference being not significant.

C. Progress in the Experiment to combine the Lint Length and Quality of V. 135 with the High Lint Yield per acre of Montserrat Sea Island.

'Selfed' progeny of the first and second backcrosses of V. 135 x Montserrat Sea Island were grown in pedigree culture this season.

It appears that the object of this experiment is being attained, as quite a number of plants on analysis have been found to have combined the characters long lint and high lint index. A large number of selections have been made for further study.

D. Experiments with Perennial Cottons.

Although the selection "C. 1" discovered by Mr. Simmons in Carriacou a few years ago has been sufficiently developed to enter commercial cultivation (2,800 acres) in Carriacou this year (under the name of 'Antilles Cotton') it is still considered that it is inferior in yield to Moco. Consequently, work with Moco strains, Moco x C. 1 and Moco x Marie Galante backcrosses is still being pursued with the object of producing strains superior to C. 1.

The two most disadvantageous characters which Moco possesses are (1) very weak staple and (2) naked seeds. By selection some of the Moco strains are now pure for 'tufted' seeds and although these are also pure for a lint length value of 48 mm. the weakness of their staple has not yet been corrected. The high rainfall conditions of St. Vincent are apparently unsuitable for this work, so the policy now adopted is to perform the preliminary experiments at this Station and immediately send any promising material to Carriacou for continuation work. In this manner selections for correct environmental conditions can be made.

Much attention is now being paid to C. 1 x Moco backcrosses as it is thought that it will be possible to breed strains combining the desirable characters of both types.

SECTION V.

REPORT ON THE WORKING OF THE GOVERNMENT COTTON GINNERY FOR PERIOD 1ST. JANUARY TO 31ST. DECEMBER 1934.

Ginning and Baling.

The total quantity of seed-cotton received for ginning was 186,034 lb. which consisted of 159,166 lb. white Sea Island and 28,868 lb. stained. The lint obtained was 45,546 lb. white and 6,356 lb. stained, giving a total of 51,902 lb.

The figures for the previous season were 80,278 lb. white and 10,339 lb. stained, giving a total of 90,617 lb.

The lint obtained from white Sea Island cotton during the 1932-33 crop was 20,939 lb. and that from the stained 2,664 lb. making a total of 23,603 lb.

Oil Expressing and Refining.

Oil was expressed from 384,776 lb. of cotton seed, which included 55,918 lb. received from the Kingstown Cotton Factory, 50,001 lb. from another Ginnery and 164,816 lb. of Marie Galante seed obtained from the Union Island Ginnery in the St. Vincent Southern Grenadines.

The quantity of seed from which oil was expressed during the previous season was 448,677 lb.

The quantity of oil refined for the season was 2,602 gallons, all of which was sold locally although prices had to be reduced in order to meet the competition of imported oil.

The residue of the oil refining kettle was used for soap making—1,428 bars of soap each weighing approximately 2 lb. were manufactured.

Purchase of Cotton on Co-operative System.

The advances made on Sea Island seed-cotton for the 1933-34 crop were 3 cents per lb. on white and $\frac{3}{4}$ cents per lb. on stained. The purchases amounted to 118,629 lb. white and 18,686 lb. stained making a total of 137,315 lb.

The figures for crop 1932-33 were 58,665 lb. white Sea Island and 6,036 lb. stained, a total of 64,701 lb.

The lint obtained was 33,861 lb. white and 4,963 lb. stained, a total of 38,824 lb.

A bonus of 57% was paid on the cotton purchased during the year 1932-33.

Purchase of Corn on the Co-operative System.

During the year under review no corn was purchased, owing to large stocks remaining on hand from the 1931–32 and 1932–33 crops. These stocks have since been disposed of.

Other Operations.

20,280 lb. cob corn were shelled and 12,966 lb. of corn owned by private individuals were ground into meal.

Grain etc. fumigated and stored in the moth-proof rooms of the Ginnery totalled 3,852 lb.

8,212 lb. cotton seed were selected and disinfected for planting.

30,814 lb. of stained cotton seed were disintegrated for use as manure.

The summary of operations and transactions for the last two years is as follows :—

	1932–33	1933–34.
Seed-cotton received and ginned ...	90,716 lb.	186,034 lb.
Cotton seed expressed ...	448,677 „	384,776 „
Cotton seed disintegrated ...	13,001 „	30,814 „
Seed-cotton purchased ...	64,701 „	137,315 „
Corn Purchased ...	42,031 „	—
Corn kiln-dried ...	39,784 „	—
Corn shelled ...	25,026 „	20,280 lb.
Corn ground into meal or stockfeed ...	9,399 „	12,966 „
Cotton seed selected and disinfected for planting ...	7,295 „	8,212 „
Grain etc. fumigated and stored ...	5,922 „	3,852 „
Cotton seed oil expressed ...	3,435 gall.	2,602 gall.
Soap manufactured ...	987 bars	1,428 bars
Cotton seed meal delivered ...	264 tons.	133 tons.

SECTION VI.

REPORT OF AN ENTOMOLOGICAL INVESTIGATION IN ST. VINCENT.

By J. G. MYERS, Sc.D., F.R.E.S., F.Z.S., Biological Control Research Officer.

I. Introduction and acknowledgments.
II. Itinerary.
III. General ecological considerations.
IV. Sugar-cane moth-borers (*Diatraea* spp.)
1. Infestation and distribution.
2. Wild host-plants.
3. Natural enemies.
V. Arrowroot pests.
VI. Cotton pests.
VII. Banana pests.
VIII. Summary.
IX. References.

I. Introduction and acknowledgments.

The brief visit here reported on arose out of the need for more definite information about cane pests in St. Vincent with a view to their control and for comparison with their status in the other islands. I was instructed to study the moth-borer position and also to advise on arrowroot and cotton pests. Incidental observations were made on other insects during rather less than a week's stay. Owing to the courtesy of His Honour the Administrator, Mr. A. Grimble, C.M.G., and the energy and enthusiasm of the Agricultural Superintendent, Mr. A. K. Briant, I was enabled to see a very considerable part of the island. Mr. Briant and (or) the Agricultural Assistant, Mr. C. K. Robinson, accompanied me on every field excursion, and I am greatly indebted to them both for their very keen interest and assistance. Mr. S. H. Evelyn, the Cotton Research Officer, was also most helpful. I owe very much finally, to the hospitality of planters throughout the island.

II. Itinerary.

4th Nov., arrived St. Vincent about 5 p.m. Visited Botanic Station and vicinity. 5th., a.m., Experiment Station ; p.m., Brighton and Diamond. 6th., a.m., Experiment Station (Cotton) ; p.m. Pembroke. 7th., leeward estates north of Pembroke, to Richmond Vale. 8th., windward estates to Sandy Bay. Late afternoon and evening, walked over Soufrière to Richmond Vale, on the leeward coast. 9th., returned Kingstown 9 a.m., but heavy rains rendered field work impossible, morning and afternoon. Discussion of arrowroot programme with Mr. Robinson. 10th., a.m., Diamond, p.m. Marriaqua Valley. 11th., Young's Island. Sailed for Trinidad 11 a.m.

III. General ecological considerations.

Much important ecological information is contained in the recent soil report of Professor Hardy and his collaborators (1934). There are further data in Myers (1931), but so far as I am aware there has been no general study of the plant ecology. The island, about 130 sq. miles in area, is highly mountainous (rising to 4000 feet), well-watered and with a generally high rainfall, the effects of which are considerably offset by uniformly light soils, derived largely from recent volcanic ejectamenta, and very little retentive of water. As a result of the latter and of good natural drainage the relative atmospheric

humidity is comparatively low, and the island is ecologically to be counted among the drier of the Lesser Antilles. This is reflected in heavy incidence of scale-insects and of the accompanying unsightly "black blight" fungus on a variety of plants.

The original vegetation has been profoundly modified below 2000 feet by settlement even where not by actual cultivation. Three zones can, however, be distinguished, and in this report characterised only briefly: (1) a lower zone, below about 1500 feet, corresponding with the "middle belt" of Grenada but extending everywhere to the coast, since there is no dry deciduous scrub belt as in Grenada. The chief woody plants are *Tecoma leucoxylon*, *T. stans*, *Andira inermis*, *Hymenaea Courbaril*, *Psidium guayava*, *Croton* spp., *Leucaena glauca*, *Gliricidia maculata*, *Cassia bacillaris*, *Lantana* spp., *Bursera simaruba*, some logwood, and of course, numerous mango, breadfruit and tamarind trees. The chief conspicuous grasses are *Valota insularis*, *Pennisetum setosum*, *Paspalum fimbriatum*, Guinea grass (*Panicum maximum*), *Axonopus compressus*, *Sporobolus indicus*, *Vetiveria zizanioides*, Johnson grass (*Sorghum halepense*). The original vegetation of this belt, judging by remnants on the steeper slopes of the deeper leeward valleys, was dominated at least in certain areas, by *Acrocomia* palms and consisted of tropical rain-forest of a somewhat drier type than in the next zone. (2) a moist rain-forest belt above about 1500 feet, corresponding with the "mountain belt" in Grenada. Of this I saw only the Soufrière type, which is obviously still "second-growth" consequent on the famous 1902 eruption, and dominated by *Inga*, *Cecropia*, *Heliconia Bihai*. Plant elements of wet rain-forest, *e.g. Xanthosoma*, *Heliconia Bihai*, *Inga*, *Hedychium*, *Piper*, follow the water-courses down the deep leeward valleys to about 400 feet. (3) Beginning at about 2000 feet on the Soufrière, is a belt of scrub passing soon into an alpine fell-field zone of sparse herbs and other low plants, which in comparison for instance with Mt. Misery in St. Kitts, has probably been extended downward by the effects of the eruption.

Agriculture is largely confined to the lower zone and about 60 per cent. of the whole island area is said to be under cultivation—thus a greater proportion than in Grenada. There is a considerable peasant cultivation, and the high relief, and absence of any very considerable flats,—all these tend to comparative restriction and isolation of areas under any one crop, though the large coconut estate of Orange Hill is one exception. Insectivorous small birds are generally much more abundant than in Grenada. So also is the mongoose, perhaps partly owing to the more favourable climate and partly to the fact that dogs are restricted by a licence (though only half the amount) in the country as well as in the town. As a result the useful ground-lizard (*Ameiva aquilina*) is so rare that it was reported extinct (Barbour, 1930); but I was able to find a few at one point on the windward coast. Leaf-lizards (*Anolis vincentii*) are exceedingly abundant up to at least 1200 feet. The giant toad (*Bufo marinus*) which has been introduced and established in so many of the islands from Grenada to Porto Rico and Jamaica, and was recently imported into Hawaii against insect pests, is not present in St. Vincent. The introduction of vertebrates is usually attended with more risks and uncertainties than that of specifically parasitic insects, and the best opinion is generally opposed to it; but in view of the clean record of this toad, and of the careful study made of it in Porto Rico, I recommend that it be imported into St. Vincent.

IV. Sugar-cane moth-borers (*Diatraea spp.*).

The remarks made in my recent Grenada report anent the fact that moth-borers (*Diatraea*) are much less prevalent in peasant cultivations than under estate conditions apply also to St. Vincent; but there is a tendency in the latter island for the estate cane areas to be larger and more continuous. As Hardy states, the chief sugar-cane lands at the present time are situated on

the broad coastal plain lying between Georgetown and Orange Hill in the north-east, and on the flat alluvial plains at the mouths of the rivers of the south-west leeward coast", and both these districts offer more extensive flats than are anywhere available in Grenada. We should therefore expect the St. Vincent infestation to be somewhat higher. Actually it is slightly lower (joint infestation 8 per cent., as compared with 9 per cent.), but the difference is not very significant, especially as the stalk infestation is rather higher (48 per cent., as compared with 42 per cent. in Grenada). The joint infestation, it may be mentioned, gives, of course, the truer index of damage. There are as in Grenada two species of moth-borers attacking cane in St. Vincent, namely the black-headed (*Diatraea saccharalis*) and the yellow-headed (*D. canella*).

1. *Infestation and distribution.*—As in Grenada, the infestation of representative randomised stools was examined wherever canes were found, and often plant fields were not available. The samples, totalling 445 canes (with 4854 joints) and shoots showed 52·7 per cent. of the shoots killed by *Diatraea*, 48 per cent. of the stalks bored and 7·8 per cent. of the joints, the corresponding Grenada figures being 43·2, 42·3 and 8·9 respectively. This involves a loss in final sugar production in St. Vincent, of about 7 to 8 per cent. This, while very far from negligible, is unusually low for the Lesser Antilles, but may be expected to increase if and when cane cultivation is extended to larger areas, under estate conditions.

Most of the canes examined were BH 10/12, which is by way of being the standard variety throughout the island estates. Next came Ba 11569 and POJ 2878, while the peasant canes are largely Bourbon. Both on leeward and on windward estates I saw some magnificant canes, with, on the north-east especially, surprisingly low infestation. A sample stool of 1st ratoon POJ 2878, for instance—a variety usually considered very susceptible to borer attack—yielded 21 splendid canes, not one of which was bored.

The average joint infestation on the leeward coast estates was 8·8 per cent. and on the windward 6·1. This is correlated with the lower rainfall of the windward slopes.

The high infestation of young shoots (over half of them killed) is associated with the prevalence of the yellow-headed borer *Diatraea canella*), which strongly prefers shoots to hard canes.

2. *Wild host-plants of borers.*—Of great importance in the borer question, especially from the point of view of biological control, are the number and distribution of wild host-plants. The following wild grasses were found infested with borer in St. Vincent :—

Valota insularis. with *Diatraea saccharalis*.
Coix lacryma-jobi, with Job's Tears, or Job's seeds, with *D. saccharalis*.
Panicum barbinode, Para grass, with *D. saccharalis*.
Cymbopogon citratus, Lemon grass, with *D. canella*.
Vetiveria zizanioides, khus-khus grass, with both species.
Eleusine indica, with both species.
Paspalum virgatum, „ „ „

These are largely weed-grasses, save lemon-grass, which is a garden plant, especially beloved of peasants, and khus-khus, which is used very extensively (much more than in Grenada) for planting on road-side banks. *Valota* is a common roadside and wasteland grass, as also is *Eleusine*. Job's Tears grows in great abundance along all the lower courses of most of the streams, especially on the leeward side. *Paspalum virgatum* is widespread as a roadside grass in all the wetter and higher areas, where it takes the place of the *Valota* which prefers lower and drier sites. Both these two grasses, and khus-khus, support a large borer population often far distant from the nearest cane cultivation and with Job's Tears, are the four most important wild hosts. This list of wild grass hosts

is probably very far from exhaustive. There are several other abundant grasses in St. Vincent which have been recorded elsewhere as occasional hosts of *Diatræa* spp. These include the giant reed or roseau (*Gynerium sagittatum*), *Paspalum saccharoides* (which occurs right up to the lip of the Soufrière Crater), *Setaria barbata*, *Leptochloa virgata*. Guinea grass is said to be a host but I have never found it attacked. The wild grass-hosts serve as a reservoir of borer infestation, but also as a reservoir for borer parasites, which are usually much more abundant in them than in cane.

Maize, which I did not find attacked in Grenada, is commonly very heavily infested by the cane borer (*Diatræa saccharalis*) in St. Vincent.

3. *Natural enemies.*—Both the time and material procurable were insufficient to yield adequate figures of the extent to which the borer is attacked in sugar-cane and grasses, by its various natural enemies. Parasites of *Diatræa* may be divided into those attacking eggs, larvæ and pupæ respectively. Trinidad would appear to be the northern limit of pupal parasites. What is of greater practical importance (since pupal parasites are of little value in *Diatræa* control) is the fact that the two occasionally efficient Tachinid parasites (*Paratheresia claripalpis* and *Stomatodexia diadema*) found as far north as Trinidad, do not occur in St. Vincent.

As regards egg-parasites, the larger one (*Prophanurus alecto*) is much more abundant than *Trichogramma minutum*, though the latter is not so scarce as in Grenada.

There follows a list of the parasites of *Diatræa* in St. Vincent :—

Attacking the egg:	*Trichogramma minutum.*
	Prophanurus alecto.
Attacking the larva:	*Microdus stigmaterus.*

As elsewhere, the larval parasites attack much more readily and frequently the borers in wild grasses than those in cane. The combined attack of the above parasites, especially on the borer population in cane, is probably almost negiligible economically, and there is a clear and promising field, as in Grenada for the introduction of one of the three more efficient of the Tachinid parasites known (*Lixophaga*, *Paratheresia* and *Metagonistylum*), and of a specific parasite, when found for *Diatræa canella*. From ecological considerations I believe that *Lixophaga* or *Paratheresia* is indicated for introduction against *D. saccharalis*. I suggest that, as the present borer infestation is comparatively small, the decision may wait a year or two until we know the results of experiments with both these flies now under way in Antigua and Barbados. In the meantime it would be advisable to survey the infestation from time to time, and I would suggest that arrangements be made for Mr. Box, who is in charge of borer work in the Leeward Islands and in St. Lucia, to pay periodic visits. He could probably initiate mill surveys during the grinding season, which could be supervised, in his absence, by the Assistant Agricultural Superintendent.

V. Arrowroot Pests.

Since the arrowroot crop had been the subject of special full-time research by Mr. C. K. Robinson, under the auspices of the Co-operative Arrowroot Association, while its pests had been studied by Mr. Urich on two successive visits, much more information was available than in the case of sugar-cane. I need not recapitulate Mr. Urich's excellent report (in *Tropical Agriculture*).

In addition to my own field observations I had the benefit of the fullest discussions with Mr. Robinson, whose experimental programme seemed to me very well thought out, and I had read all his reports.

The possibility of biological control for the arrowroot worm (*Calpodes ethlius*) has long been envisaged. I should therefore like to emphasise the importance of what we may call Marshall's law—namely—that the cost of a biological control project should not be greater than half the amount of the estimated annual damage. While this may not apply to continental areas where

immense *potential* issues are at stake, in small Colonies with limited means it is a very useful practical guide. The necessity of estimating with some accuracy the damage caused by the arrowroot worm is the more pressing from the fact that, as I understand, there are some planters who believe that no loss whatever is inflicted on the crop. There are, however, five points under which damage may be visualised and should be investigated:—

a. Direct damage in the destruction of plants.

b. Depletion of rhizomes by new shooting to replace foliage destroyed.

c. The new shoots, being more attractive, initiate a new cycle of attack.

d. Cost of extra weeding, when the cover is opened up by defoliation, and many more weeds gain entry.

e. Damage done by the weeders, especially when the crop is advanced.

Mr. Robinson has already experiments in progress to determine the loss (under *a*—*c*) by measuring exactly the effect of *complete* defoliation at different periods in the growth of the crop. We shall then have a standard by which to estimate the results of various degrees of *partial* defoliation. These experiments should be carried out both as field plot tests and as pot-experiments.

The second essential preliminary to any scheme of biological control is a thorough study of the natural enemies already present in St. Vincent and an estimate of their efficiency under various conditions. Mr. Robinson has already made considerable progress in this work, and is capable of carrying it to a useful conclusion provided he receives prompt entomological assistance from time to time, especially with regard to the identification of insects reared. This could best be accomplished by putting him in close touch with Mr. Box, or with one of the entomologists at the College.

The following parasites are now known in St. Vincent, as a result of the investigations of Harland, Urich and Robinson:—

Attacking eggs:	*Trichogramma minutum*
	Undetermined parasite (Harland)
Attacking larvæ and (or) pupæ	*Elachertus meridionalis*
	Eucelatoria australis
	Sarcophaga lambens (= *Sarcodexia sternodontis*)
	Brachymeria annulata (new record, Robinson).

In discussing the efficiency of egg-parasites, it is most important that we should know the extent of young larval mortality—*i.e.*, the proportion of young larvæ which die in any event before establishing themselves in a feeding position. This we do not know, and it should be ascertained by exact counts in connection with further biological studies of the pest itself.

The results of previous investigators show that the most efficient parasites now present are "Tachinids", but owing to the great difficulties of study in this group, we are almost completely in the dark as to which insects are really doing the work. *Eucelatoria australis* is a true Tachinid in the strict sense and is therefore probably the most efficient, while *Sarcophaga lambens** is a Sarcophagid, with a wide range of hosts elsewhere and no record of efficiency. Yet all the flies reared from *Calpodes* pupæ and submitted to me by Mr. Robinson are Sarcophagids. The position is further complicated by the fact that Mr. Urich reared two species of "Tachinid flies" from pupæ, and whether these are the two previously recorded or two additional species, is

*There has been much confusion in the identification of this species. It was described by Townsend in 1892 as *Sarcodexia sternodontis*, which was misprinted in Harland's report as *Sariodexia* and repeated as such by Urich. Aldrich (1930) has shown that the correct name is *Sarcophaga lambens*.

not known. The question is highly important, since Mr. Urich has also found two Tachinids attacking the larva in Trinidad, namely, *Achaetoneura nigripalpis* and *Exoristoides urichi*, and *if these are not already present in St. Vincent*, they, or the more effective of the two, *should certainly be introduced into St. Vincent, as the most promising foreign parasites at present known.* There is, then, pressing need for the continued rearing, on a large scale, of all the fly parasites present in St. Vincent, and the prompt submission of specimens to a specialist in this difficult group. Without that we are simply working in the dark. We have already a long list of parasites known to attack the arrowroot worm in other countries. Apart from the Trinidad Tachinids above-mentioned, the most noteworthy is an egg-parasite, *Xenufens rushini* which in Cuba kills up to a 100 per cent. of the eggs. But for all we know at present, the unidentified St. Vincent egg-parasite listed above as reared by Dr. Harland may be the same species, so that here again we are handicapped by the need for further rearing and investigation in St. Vincent.

The small wasp, *Apanteles talidicida*, which attacks the larvæ in Trinidad, is by no means promising, and the abortive and perhaps somewhat premature attempt which has already been made to introduce it into St. Vincent need not be repeated, more especially as Mr. Robinson had previously reared in St. Vincent a species of *Apanteles* which may well be the same. More material of this St. Vincent *Apanteles* is urgently needed for determination. This is a genus in which identification can be readily and quickly secured.

Bound up with the question of parasites is that of alternate host-plants. These include chiefly garden cannas and the wild *canna coccinea*. The former seem to be favourite garden plants of the arrowroot planters. It is important that the extent of attack by various parasites on the *Calpodes population* of these alternate host-plants should be studied. *Maranta indica*, a kind of wild arrowroot, is said to be rare, but ought to be investigated.

We now come to the predatory enemies of the arrowroot worm. These are undoubtedly at present more important in St. Vincent than the parasites. The biological investigator is singularly fortunate in having, in *Calpodes*, through the sedentary habits of its intermediate stages, and the easy recognition of the bent-over leaf shelters of larvæ and pupæ, a pest in which it is unusually easy to measure with some exactitude the incidence of predatism.

The chief predators of the larvæ are wasps or Jack Spaniards (*Polistes annularis*), lizards (*Anolis vincentii*) and birds. The pupæ are chiefly attacked by birds, the pupal shelters being apparently largely impregnable to lizards and wasps. Large centipedes (not yet named), which are not uncommon in arrowroot fields, also eat the pupæ.

The Jack Spaniard position in St. Vincent is of extreme biological interest not only in connection with the arrowroot industry. It has attracted the attention of every previous investigator, since these wasps are far more abundant in St. Vincent than anywhere else I know. To this widespread and everpresent abundance of an efficient caterpillar-hunter has been attributed the comparatively low incidence of the cotton worm (*Alabama*) in St. Vincent, when other islands have been severely attacked. Some *e.g.* Ballou, believe that this particular wasp (*Polistes annularis*) is more efficient than the related Polistes spp. of the other islands, and following this idea, have introduced the St. Vincent form into some of the Leeward Islands, where its failure has been attributed to the presence of a parasitic moth (*Diaymolomia pegasalis*) said to be absent from St. Vincent. Harland, on the other hand, considers the greater abundance of this and certain other natural enemies of cotton pests in St. Vincent, to be due to the much greater extent of "bush" and uncultivated land in the latter island, as compared with the other cotton islands and especially with Barbados. I believe Harland is right in recognising that it is a question of relative abundance of the St. Vincent Jack Spaniard rather than of its relative efficiency. But if we compare Grenada, St. Lucia and Dominica,

with their equally large or even much greater proportion of untilled lands and "bush", it is obvious that his explanation of this abundance is invalid, for *Polistes* wasps are by no means particularly abundant in these three islands. The key to the position lies, I believe, in the arrowroot industry itself, which is largely confined to St. Vincent and is practised in almost every part of the island. Since arrowroot fields are replanted at the time of harvesting, and *Calpodes* eggs are laid on new leaves within three weeks of planting (Robinson) there is a practically continued supply of arrowroot worms throughout the year—for the Jack Spaniards a perennial food-supply which is not offered by any other species of caterpillar that I know, at least on any comparative scale. The supply of cotton worms (*Alabama*), for instance, is very much more periodic—restricted to a very few months, and in some years very scanty. The arrowroot worm therefore, I believe, acts as an immense reservoir of food for its *Polistes* and is the one single factor which enables it to maintain such an immense population from year to year.

The effect of lizards in eating arrowroot worms needs careful investigation, involving the examination of stomach contents, and the observation of habits in the field.

Mr. Robinson has already shown, by stomach examination, that the blackbirds (*Holoquiscalus* : the specific name is under discussion) feed on *Calpodes*. An examination of 100 pupal leaf folds taken at random, towards the end of an infestation, the traces of pupæ eaten by birds being easily distinguished from those which had given rise to butterflies, showed a total pupal mortality of 32 per cent., of which 28 was due to blackbirds. In addition to continued observation of bird-habits in the field, experiments should be undertaken to ascertain the possible value of bird-perches of bamboo or other convenient sticks, placed at frequent intervals in the fields. The great importance of wind-breaks and other plantations of trees and bushes, as shelter and breeding-grounds for insectivorous birds should be emphasised.

VI. Cotton insects.

Cotton pests are being combatted in St. Vincent with considerable success by three main methods, namely, rigid close season, destruction of alternate host-plants and breeding of resistant varieties. The last-named having proved very effective against such cryptogamic diseases as angular leaf-spot, is now being initiated at the Cotton Experiment Station, against insects too.

Cotton stainers (*Dysdercus delauneyi* were once, and probably still are the worst insect pest of cotton in St. Vincent. I found them numerous on *Thurberia* at the Cotton Station. They are kept down by close season regulations and by the vigorous destruction of alternate hosts. This involves considerable work every year, especially in cutting the new shoots of John Bull tree (*Thespesia populnea*) and trimming such silk-cotton (*Ceiba pentandra*) as are not destroyed. The destruction of the abundant *Sterculia* trees—a favourite host in the rain forest of the higher windward slopes, has been given up as economically impracticable. These with occasional overlooked hosts, and possibly infringements of the close season and seed-disposal regulations, serve to maintain a by no means inconsiderable stainer population. The only economic means of avoiding this constant menace and saving the appreciable loss which the stainer still inflicts on the industry, is biological control. With the knowledge of a strikingly efficient Tachinid parasite (*Acaulona*) of cotton-stainers in Peru the prospects of biological control are decidedly good, given adequate preliminary study of the host in St. Vincent, and the parasite in Peru.

Much the same remarks apply to the pink bollworm (*Platyedra gossypiella*). Here, as elsewhere, the most important measure of control lies in a rigid close season. There is, however, no reason against, and much promise from a well-thought out scheme of biological control, such as has already

been projected for the other cotton islands. It cannot be too strongly emphasised, however that our ignorance of pink bollworm biology under West Indian conditions is profound. Its extraordinary fluctuations in numbers from year to year and from island to island are completely inexplicable from our present knowledge. Any scheme of parasite introduction must be based on the results of two or three years' intensive local ecological research, or it is foredoomed to failure.

Mole crickets, I am informed by Mr. S. H. Evelyn, are among the worst pests of young cotton, and the chief cause of the need for extensive supplying. Here, again, considerable study of the insect is required. I am not aware that it has even ever been identified as to the species.

Cotton aphis (*Aphis gossypii*) is locally and occasionally destructive. I saw several infestations, both on leeward and windward estates. In every case ladybirds were plentiful and evidently doing good work, especially the unspotted red one (*Cycloneda sanguinea*), the spotted species (*Megilla maculata*) being much less abundant, I saw, however, no sign whatever of *Hymenopterous* parasites of these aphides. Steps should certainly be taken to ascertain whether these are present, with a view to introducing them if they are not.

VII. Banana pests.

It was not within my instructions to examine banana pests, but I was struck incidentally by the apparent absence of the banana-borer (*Cosmopolites sordidus*)—by far the most important pest of this crop. Neither Mr. Briant nor the Banana Instructor, Mr. George Fraser, had seen an infestation. In view of the development of the banana industry, it seemed to me of tremendous importance to ascertain whether the island were really free from banana borer, with a view to taking every possible step to prevent its entry. A hard search, with Mr. Robinson, on the afternoon before I sailed, demonstrated its presence in a village garden at Mesopotamia, but it is certainly a comparatively rare insect in St. Vincent.

VIII. Summary.

1. The giant toad (*Bufo marinus*), which has proved its value as a destroyer of agricultural pests on some of the other islands, is not present in St. Vincent. I suggest that it be introduced, *e.g.*, from Trinidad.

2. The two sugar-cane moth-borers (*Diatraea saccharalis* and *D. canella*) in St. Vincent infest this crop to the extent of about 48 per cent. of the stalks and 8 per cent. of the joints. This corresponds to a final loss of about 7—8 per cent.

3. If and when the industry is extended to larger areas, under estates conditions, the infestation may be expected to increase.

4. Seven different wild grass hosts are known in St. Vincent. Of these four are important as reservoirs of the borer, but they act also as reservoirs of parasites, since in them the borer is much more accessible to these enemies than in cane.

5. Of the three parasites of *Diatraea* found in St. Vincent, none is of much practical importance, and there is a clear field for the importation of either *Lixophaga* or *Paratheresia* (efficient Tachinid parasites), and of a specific parasite, when found, for the yellow-headed borer (*D. canella*).

6. The decision as to *Lixophaga* or *Paratheresia* should be deferred till the results of experiments in Antigua and Barbados are available.

7. The greatest preliminary need in the investigation of the arrowroot worm (*Calpodes ethlius*) is a just estimate based on experiment and expressed in £ per annum, of the loss it inflicts on the industry. Mr. Robinson has already arranged such experiments.

8. A second essential is a thorough study of the natural enemies, more particularly parasites, already attacking the pest in St. Vincent. Special attention should be paid to the Tachinid and Sarcophagid flies, with a view to introducing one or more species from Trinidad, if investigation shows they are not already present.

9. Bound up with the question of parasites is that of alternate host-plants, which should be thoroughly studied with regard to incidence, infestation and parasitism.

10. Jack Spaniards (*Polistes annularis*) are phenomenally abundant in St. Vincent as a result of the large and perennial food reservoir supplied by the arrowroot worm, on which they are very effective predators.

11. Other predators are lizards and birds. Experiments in the encouragement of the latter should be undertaken with bird-perches (bamboo etc.) posted at frequent intervals in the fields.

12. In spite of rigid close season and destruction of alternate hosts, cotton stainers and pink bollworm are by no means negligible pests in St. Vincent. Both should be the subject of thorough local ecological research as a preliminary to a project of biological control, which is very promising in both cases.

13. An effort should be made to ascertain whether any parasites (as distinct from predators) of the cotton aphis occur, with a view to importing some if they are lacking in St. Vincent.

14. The banana borer (*Cosmopolites sordidus*), is present in St. Vincent but it is at present a comparatively rare insect.

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